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NATIONAL WORKSHOPS ON HOSPITAL WASTE INCINERATION AND HOSPITAL STERILIZATION

SAN FRANCISCO
MAY 10-12, 1988

BALTIMORE
MAY 24-26, 1988

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PROCEEDINGS

HOSPITAL WASTE INCINERATION AND HOSPITAL STERILIZATION WORKSHOPS

Sponsors:

California Air Pollution Control Officers Association

Northeast States for Coordinated Air Use Management

State and Territorial Air Pollution Program Administrators/
Association of Local Air Pollution Control Officials

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards

May 10-12, 1988
Golden Gateway Holiday Inn
San Francisco, CA

May 24-26, 1988
Hotel Belvedere
Baltimore, MD

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EPA-450/4-89-002

PROCEEDINGS

HOSPITAL WASTE INCINERATION AND HOSPITAL STERILIZATION WORKSHOPS

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May 10-12, 1988
Golden Gateway Holiday Inn
San Francisco, CA

May 24-26, 1988
Hotel Belvedere
Baltimore, MD

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These Proceedings contain technical papers and discussions published mostly as they were presented at the CAPCOA/NESCAUM/STAPPA/ALAPCO/USEPA Hospital Waste Incineration and Hospital Sterilization Workshops. The opinions expressed herein are not necessarily the official positions of the organizations with which the authors are associated, nor do the opinions expressed herein necessarily have the endorsement or support of CAPCOA, NESCAUM, STAPPA/ALAPCO, or USEPA.

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PROCEEDINGS OF THE HOSPITAL WASTE INCINERATION AND HOSPITAL STERILIZATION WORKSHOPS

EXECUTIVE SUMMARY

INTRODUCTION

Public agencies responsible for regulating waste disposal are devoting increasing attention to hospital waste incineration. Generation of hospital waste is increasing with growth in the health care industry as well as new developments in medical technology. Although modern controlled-air techniques allow efficient air pollution control, many older incinerators are still in use. Because of a lack of controls and poor dispersion characteristics from the stack, many hospital incinerators may be high risk point sources.

Hospital waste incineration is one aspect of solid waste management. Many states have only recently begun to inventory hospital waste incinerators and issue permits. Agencies are approaching hospital waste incineration using experience gained in the regulation of municipal waste combustion and, in some cases, hazardous waste management. The evaluation of hospital waste incineration facilities brings together complex issues of technological capability, economic and political feasibility, public opinion, risk assessment, and environmental impact.

These Proceedings are the product of twin workshops on hospital waste incineration held on May 10-12, 1988 in San Francisco, California, and May 24-26, 1988 in Baltimore, Maryland. The workshop sponsors were California Air Pollution Control Officers Association, Northeast States for Coordinated Air Use Management, State and Territorial Air Pollution Program Administrators/ Association of Local Air Pollution Control Officials, and the U.S. Environmental Protection Agency Office of Air Quality Planning and Standards. More than 130 representatives of 82 government agencies and 10 private organizations in the United States and Canada, with jurisdictions in 35 states and provinces, attended one or both workshops.

The primary goals of the workshops were to present the most advanced research and policies on hospital waste incineration being pursued in the regulatory sector, encourage the formation of networks among those involved, and improve permitting and enforcement through exchange of information. Hospital waste sterilization was also included because it is a related source of increasing regulatory concern. The structure of the workshops was designed for maximum interaction among the participants. From these discussions emerged several themes for future action involving research needs, approaches to waste management, and permitting policies.

WORKSHOP SESSIONS

The workshop sessions on the first day were devoted to defining the problem and discussing technological solutions. On the second day the sessions discussed policy issues and evolving regulatory requirements.

The workshop sessions included six main topics:

- Manufacturers' Panel Discussion
- Source Data and Stack Testing
- Topics of Special Concern
- Agency Permitting Experiences
- Agency Regulations and Guidelines
- Hospital Sterilizers

In the Manufacturers' Panel Discussion, panelists outlined the historical development, design, and costs of hospital incinerators and their air pollution control systems. The importance of the "three T's" — retention time and temperature in the secondary chamber, and combustion turbulence — in minimizing emissions has been established. These parameters are especially important for small (less than 10,000 cfm) incinerators.

Panelists identified the major cause of high emissions as poor operating practices rather than technological inadequacy. Poor operation may also cause incomplete burnout. Participants identified needs for consistent regulations and for operator training. Several participants stated that operator training is important to include as a permit requirement. Further development of training and testing procedures is needed.

Representatives of four jurisdictions presented the second main topic, Source Data and Stack Testing. They provided an overview of emissions data, how testing is conducted, and results of recent surveys. Stack testing is extremely costly. Participants discussed the effectiveness of design requirements and combustion guarantees as alternatives to extensive compliance testing. Participants also expressed concern that control of emissions of metals may be poor.

A similar discussion took place regarding the value of continuous emission monitoring (CEM). The costs of CEM systems are prohibitive for small units. Facilities with good operating practices and basic instrumentation (e.g. continuous temperature monitoring) may not need CEM. Agencies should decide in advance how CEM data will be used, and should provide guidelines on CEM requirements and operation. Practical CEM systems are available for many pollutants including opacity, but not yet for HCl.

The third session examined Topics of Special Concern, including pathogen survival, risk assessments, and regional facilities. Destruction of pathogens requires a higher temperature than does other waste. Tests have detected no pathogens at the stack, but the question of survival of spores is unresolved.

Another unresolved issue is the regulation of infectious waste when it is mixed with other waste. For example, pathogens can originate not only from hospitals, but also at clinics, dental offices, and the like, and enter the municipal waste stream. Public protest is likely at the slightest hint of risk from pathogens.

The issue of regional versus local facilities engendered much discussion but no decision. Regional incinerators can offer lower disposal costs due to economies of scale, but may entail higher waste transportation costs. Forthcoming state regulations will likely favor regional facilities. The costs of control equipment and CEM will also encourage the use of regional facilities. However, if existing incinerators (especially small units) are phased out, and fees at regional facilities are high, illegal dumping of waste could increase.

Also discussed were the regulation of acid gases, toxic substances and criteria pollutants, and mechanisms of dioxin formation.

The next two topics, Agency Permitting Experiences and Agency Regulations and Guidelines, were significant in meeting the primary goals of the workshops. Precedents for permits and policy decisions are evolving as agencies struggle to develop rules from case-by-case permitting experiences.

Agencies differ widely in their current practices for reviewing permit applications. An agency may consider many conditions in its permits. These include the following areas mentioned by workshop participants.

1. Requirements for risk assessment
2. Requirements for dispersion modeling
3. Opportunities for source separation
4. Requirements for waste packaging and transportation
5. Choice of substances to regulate
6. Possible "special waste" status for biomedical waste
7. Combustion controls
8. Requirements for operator training and certification
9. Requirements for stack testing
10. Requirements for CEM

Other topics discussed in the session on Agency Permitting Experiences included waste handling and ash disposal. Prospects for containerization systems are uncertain at present. Source separation schemes offer benefits in theory, but can be difficult and costly to implement. Some agencies are considering designation of biomedical waste as a "special waste" with requirements stricter than for those municipal waste, but more lenient than the requirements for hazardous waste.

Canadian agencies are working toward a National Code of Practice on the Management of Biomedical Wastes. This effort will take about two years. The Code will specify practices for transportation and ultimate disposal of biomedical wastes, ensuring the destruction of pathogens, and technical control requirements (e.g. acid gas scrubbing will probably be required). Canadian agencies are seriously considering regional facilities.

Environment Canada is in the first phase of an optimization testing program on a large regional incinerator. The tests will differ from compliance testing in that combustion conditions will be varied to define operating conditions that minimize pollutant emissions. Guidelines for handling and disposal of biomedical waste, issued by the Ontario Ministry of the Environment, were also presented and are included in the Proceedings.

This session led into the next topic, Agency Regulations and Guidelines, which examined regulatory strategies in the United States. The presenters examined possible regulatory approaches, some already being implemented, in addition to the topics of the previous session. These included the regulation of small facilities which cannot afford to install state-of-the-art controls. Some states exempt small facilities. Retrofit requirements are expected to force small facilities to close. Fewer, larger facilities would require fewer agency resources to regulate than a larger number of smaller units.

In small group discussions, participants evaluated case studies of hospital waste incinerator permitting. The small groups also discussed a comprehensive model rule, which is included in the Proceedings. While the workshops did not formally endorse the model rule, many of the concepts discussed received widespread support. Specific requirements in a rule might include the items listed above as possible permit conditions.

Because knowledge of the air pollution and health impacts of hospital sterilizers is much less developed than for incinerators, agencies which have had experience with sterilizers presented information on how to regulate and permit these facilities. Hospital sterilizers typically use ethylene oxide (EtO), a highly toxic gas, to sterilize reuseable materials and supplies. This process entails occupational risks. OSHA regulations require exposure monitoring, employee training, medical surveillance, communication of EtO hazards to employees, and precautions for safe handling and storage of EtO. Hospitals usually control occupational exposure by venting, which converts the problem into one of ambient exposure. Panelists reviewed recent permit decisions that will require emission controls for EtO sterilizers.

SUGGESTIONS FOR FUTURE EFFORTS

One purpose of the workshops was to identify important topics and trends in order to assist agencies in focusing their resources for the next few years. These future directions are grouped below under three headings: Technical Problems (areas requiring scientific research and development), Approaches to Waste Management (program development and management for the overall solid waste problem), and Regulatory Policies (improvements in permitting and enforcement).

Technical Problems

- Waste constituents
    - Develop procedures to determine composition and variability of waste in a cost-effective manner.
    - Determine the sources of Cl, metals, and pathogens.
- Combustion
    - Improve understanding of combustion and its relationship to design parameters.
    - Improve understanding of mechanisms of dioxin formation.
    - Improve understanding of pathogen survival.
- Ash
    - Improve and standardize testing methods.
    - Devise and evaluate disposal alternatives.
- Monitoring
    - Develop HCl monitoring technology.
    - Reduce costs of CEM.
- Risk assessment
    - Refine and standardize assumptions and procedures.
    - Improve knowledge of toxicity levels.
    - Improve methods for analyzing multiple exposure pathways.
    - Develop national guidance on acceptable risks and ambient levels for HCl.

Approaches to Waste Management

- Introduce/improve operator training and certification
- Improve the practicality of source reduction/source separation.
- Continue the investigation of alternatives for ash disposal.
- Improve the evaluation of risks and benefits of regional facilities versus onsite incineration.
- Improve education of the public on relative risks and benefits of all disposal alternatives.

Regulatory Policies

- Establish testing and monitoring requirements to optimize gathering of meaningful data versus cost.
- Establish combustion, stack, and control device requirements that encourage good design and operation; discourage reliance on numerical parameters alone.
- Assess the impacts of small facilities, and assess alternatives for disposal of their waste streams.
- Include operator training requirements as permit conditions.
- Coordinate air quality and solid waste permitting and evaluation.

PROCEEDINGS OF THE HOSPITAL WASTE INCINERATION AND HOSPITAL STERILIZATION WORKSHOPS

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16. ABSTRACT

The primary goals of the workshops were to present the most advanced research and policies on hospital waste incineration being pursued in the regulatory sector, encourage the formation of networks among those involved, and improve permitting and enforcement through exchange of information. Hospital waste sterilization was also included because it is a related source of increasing regulatory concern. The agenda was specifically structured to provide insight into the magnitude and nature of the problems associated with these sources, and the responsive actions taken by State and local agencies to develop regulations and issue permits.

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HOSPITAL INFECTIOUS WASTE INCINERATION AND HOSPITAL STERILIZATION WORKSHOP

MAY 10-12, 1988
GOLDEN GATEWAY HOLIDAY INN
SAN FRANCISCO, CA

SPONSORS:

California Air Pollution Control Officers Association (CAPCOA)

State and Territorial Air Pollution Program Administrators/ Association of Local Air Pollution Control Officials (STAPPA/ALAPCO)

U.S. Environmental Protection Agency (EPA)

May 10: Nature of Hospital/Infectious Waste Incineration Problem

7:30-8:30 REGISTRATION

Moderator: Wayne Cropp, Chattanooga APC

8:30 **Opening Remarks**
Dave Howekamp - EPA Region IX
Milt Feldstein - Bay Area AQMD

8:45 **Overview of the Problem**
David Painter - US EPA OAQPS
Anders Carlson - New York DOH
Lloyd Yandell - Kaiser Hospital, San Francisco

10:00 BREAK

10:15 **Manufacturers' Panel Discussion**

Steve Shuler - Ecolaire Corporation
Bob Lee - Consumat Systems Inc.
James Kidd - Cleaver Brooks

Noon LUNCH

Moderator: Mike Trutna, EPA OAQPS

1:00 - **Source Data and Stack Testing**
P.K. Leung - Environment Canada
Gary Yee - California ARB
Bob Waterfall - New York DEC
Vlado Ozvacic - Ontario Ministry of Environment

2:30 BREAK

2:45 - Topics of Special Concern - Pathogen Survival, Risk Assessments, Regional Facilities
Joann Held - New Jersey DEP
Mike Tierney - Wisconsin DNR
Dave Campbell - Environment Canada

4:00 - Open Discussion

Moderator: Mike Trutna, EPA OAQPS

5:00 ADJOURN

May 11: Hospital/Infectious Waste Incineration Regulatory Experiences

Moderator: Don Ames, California AMB

8:00 - Agency Permitting Experiences
Lynn Fiedler - Michigan DNR
Wayne Cropp - Chattanooga APC
Jim Salovich - Bay Area AQMD
George Aburn - Maryland Air Mgmt. Adm.

10:15 BREAK

10:30 - Agency Regulations and Guidelines
Wally Sonntag - New York DEC
Jim Salvaggio - Pennsylvania DER
Dan Speer - San Diego AQMD
John Manuel - Ontario Ministry of the Environment

12:30 LUNCH BREAK

Moderator: Wayne Cropp, Chattanooga APC

1:30 - Discussion Groups - Case Examples
Discussion Leaders - Lynn Fiedler, Joann Held, Wallace Sonntag, Nancy Seidman

3:00 BREAK

3:15 - Discussion leaders report on their groups

3:45 - Open Discussion

5:00 ADJOURN

May 12: Hospital Sterilizers and Site Visit

Moderator: David Painter, EPA OAQPS

8:00 - **Nature of the Problem**
David Painter - EPA OAQPS
Elizabeth Gross - Dana-Farber Cancer Institute
Tim Smith - Bay Area AQMD

9:00 - **State Permitting Experiences**
Eric Wade - New York DEC
Danita Brandt - Michigan DNR
Darrell Graziani - Hillsborough County (Florida) APC

10:30 BREAK

10:45 - Open Discussion

11:15 - Wrap-up

11:30 LUNCH BREAK

12:15-3:30 Stanford University Hospital Site Visit

3:30 ADJOURN

AGENDA

HOSPITAL INFECTIOUS WASTE INCINERATION AND HOSPITAL STERILIZATION WORKSHOP

MAY 24-26, 1988
HOTEL BELVEDERE
BALTIMORE, MD

SPONSORS:

Northeast States for Coordinated Air Use Management (NESCAUM)

State and Territorial Air Pollution Program Administrators/ Association of Local Air Pollution Control Officials (STAPPA/ALAPCO)

U.S. Environmental Protection Agency (EPA)

May 24: Nature of Hospital/Infectious Waste Incineration Problem

7:30-8:30 REGISTRATION

Moderator: Michael Bradley, NESCAUM

8:30 Opening Remarks
  Jesse Baskerville - US EPA Region III
  Michael Bradley - NESCAUM

8:45 Overview of the Problem
  David Painter - US EPA OAQPS
  Ray Morrison - US EPA OAQPS
  Anders Carlson - New York DOH
  Leland Cooley - University Hospital, Baltimore City

10:00 BREAK

10:15 Manufacturers' Panel Discussion
  Steve Shuler - Ecolaire Corporation
  Jeff Gray - Consumat Systems Inc.
  James Kidd - Cleaver Brooks

Noon LUNCH

Moderator: Mike Trutna, EPA OAQPS

1:00 - Source Data and Stack Testing
  P.K. Leung - Environment Canada
  Gary Yee - California ARB
  Bob Waterfall - New York DEC
  Vlado Ozvacic - Ontario Ministry of Environment

2:30 BREAK

2:45 - **Topics of Special Concern - Pathogen Survival, Risk Assessments, Regional Facilities**
Joann Held - New Jersey DEP
Steve Klafka - Wisconsin DNR
Dave Campbell - Environment Canada

4:00 - **Open Discussion**

Moderator: Mike Trutna

5:00 ADJOURN

May 25: Hospital/Infectious Waste Incineration Regulatory Experiences

Moderator: George Ferreri, Maryland Air Mgmt. Adm.

8:00 - **Agency Permitting Experiences**
Randy Telesz - Michigan DNR
Jim Weyler - Chattanooga APC
Tim Smith - Bay Area AQMD
Tad Aburn - Maryland Air Mgmt. Adm.

10:15 BREAK

Moderator: Chris James, Rhode Island DEM

10:30 - **Agency Regulations and Guidelines**
Wally Sonntag - New York DEC
Jim Salvaggio - Pennsylvania DER
Robert Pease - South Coast AQMD
John Manuel - Ontario Ministry of the Environment

12:30 LUNCH BREAK

Moderator: Michael Bradley, NESCAUM

1:30 - **Discussion Groups - Case Examples**
Discussion Leaders - Randy Telesz, Wally Sonntag, David Painter, Chris James

3:00 BREAK

3:15 - **Discussion leaders report on their groups**

3:45 - **Open Discussion**

5:00 ADJOURN

May 26: Hospital Sterilizers and Site Visit

Moderator: David Painter, EPA OAQPS

8:00 - Nature of the Problem
David Painter - EPA OAQPS
Elizabeth Gross - Dana-Farber Cancer Institute
Tim Smith - Bay Area AQMD

9:00 - State Permitting Experiences
Eric Wade - New York DEC
Randy Telesz - Michigan DNR
Darrell Graziani - Hillsborough County (Florida) APC

10:30 BREAK

10:45 - Open Discussion

11:15 - Wrap-up

11:30 LUNCH BREAK

12:30-3:30 Johns Hopkins University Site Visit

3:30 ADJOURN

SESSION I

OVERVIEW OF THE PROBLEM

SESSION I: OVERVIEW OF THE PROBLEM

SUMMARY OF DISCUSSION (SAN FRANCISCO)

Q: What is the status of regional incineration in New York? Is there pressure from upstate hospitals to have regional incinerators?

A: (A. Carlson, NY DOH) There is state legislation to consider regional management of waste as part of the overall state plan. The options include using current municipal waste combustion facilities, having a consortia of participating hospitals, or letting hospitals build their own incinerators. No hospital is being forced to look into only one option.

Q: Please describe "universal precautions." Everything in some hospitals is being handled as infectious waste.

A: (L. Yandell, Kaiser Hospital, San Francisco, CA) The intent of universal precautions is risk management and liability reduction. Under CDC guidelines, everything in contact or indirect contact with something that had contact with a patient will be handled and transported as infectious waste or hazardous waste. It is the cheapest long-range risk management program.

Q: What is the total volume of waste you are experiencing at Kaiser Hospital (San Francisco)?

A: (L. Yandell, Kaiser Hospital, San Francisco, CA) At clinics the figures come out to about 7 pounds per patient visit and at hospitals 21-23 pounds per bed site. This does not include specialties like CD surgery which may add another 9 pounds or more.

Q: Are the figures represented just for hospitals?

A: (A. Carlson, NY DOH) Yes. The New York survey only included hospitals. It does not include veterinarians, free-standing family practices, and some elderly housing.

A: (L. Yandell, Kaiser Hospital, San Francisco, CA) Patients are being sent home earlier than in past years. Wastes that used to be generated only at hospitals may appear in residential waste. In 1989 a Joint Commission will look at the impact of home care on medical waste in San Francisco.

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SESSION I: OVERVIEW OF THE PROBLEM

SUMMARY OF DISCUSSION (BALTIMORE)

Q: Many early incinerators had short (e.g. 30 ft) stacks; modern ones have stacks 85 ft or higher. What is the effect of stack height on risk assessment results?

A: (D. Painter, EPA) No definitive answer is available yet. EPA is examining data on the impact of various stack heights.

Q: Was autoclaved waste compacted? If not, would compaction help solve problems of waste storage and handling?

A: (L. Cooley, University Hospital, Baltimore, MD) General waste was not compacted until after autoclaving. This would not solve the basic problem which is that objects remain recognizable in the waste after autoclaving. Municipal incinerator operators are sensitive to public protest and often refuse to accept waste with recognizable medical objects, even if they do not suspect contamination from the hospital.

Q: What is the status of EPA efforts to improve operator training?

A: (D. Painter, EPA) EPA is organizing a course, to be conducted by a contractor, in cooperation with the State of Maryland. This effort has only just begun.

Q: Is the course for the actual operators, and is it required by the State of Maryland?

A: (D. Painter, EPA) Details have not been worked out, and there is no current requirement.

(G. Aburn, MD DOH) Maryland would like to require such training in the future.

SESSION II

MANUFACTURERS' PANEL DISCUSSION

DEVELOPMENT OF CONTROLLED AIR, FACTORY PACKAGED, INCINERATION TECHNOLOGY IN USA

By Gene White
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Typical features of the controlled air system are as follows:

a) Emission levels of particulates are consistently low without the use of hot gas cyclones or refractory filters.

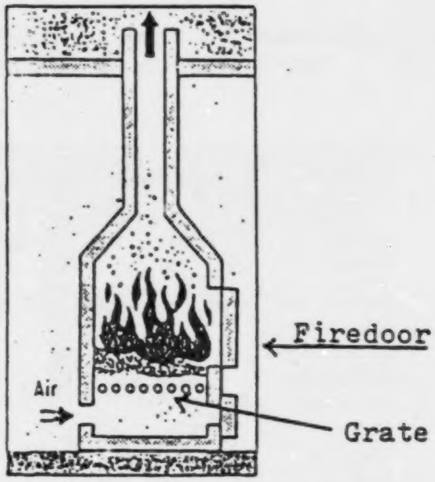
b) The incinerator is automatically loaded, preventing overloading and protecting the operator from the effects of explosion of aerosols, blowbacks and noxious fumes.

c) Waste of varying calorific values can be accepted.

d) Loading is automatic and there is little risk of operator error.

The old design incinerators in use in the USA up to the mid 1970s were of cast iron or steel and were lined with refractory brick. Figure 1 shows their design.

Figure 1



The waste was manually charged through a hinged door and initial ignition was by paper or oil-soaked cloth. Waste was burned on a grate with air rising through the grate from an air inlet below.

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Features of this method were as follows:

a) The rate of combustion air flow and of burning could not be controlled and it gave off considerable smoke and high "flyash" emission.

b) The loading method permitted overloading which resulted in excessive temperatures causing damage to the refractory brick lining.

c) The operator was not protected during loading.

d) The grate had to be replaced frequently.

A refinement was the addition of:

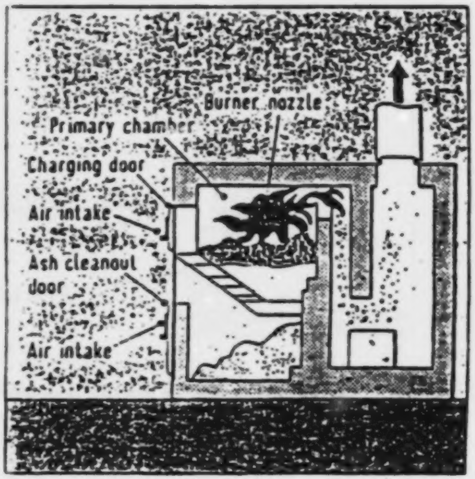
a) A burner for initial ignition of waste and for the burning of pathological waste.

b) A forced draft fan to increase turbulence and mixing in the burning chamber.

c) A reversal chamber to attempt to remove "flyash", on the premise that by reversing the direction of the emission flow larger particles of "flyash" would be deposited.

The incinerator continued to have a grate and to be charged manually. Figure 2 shows how this method worked.

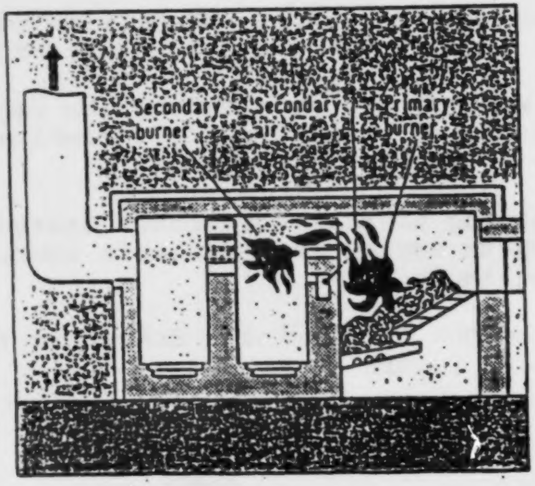
Figure 2



The benefits were that there was a thermal switch which cut off the fuel supply when a given temperature was achieved thereby saving fuel, it was possible to ignite waste automatically and there was a slight reduction in "flyash".

The next development step was the addition of an after-burning chamber to the incinerator. See figure 3.

Figure 3



The smoke and emission generated by the unit in Figure 2 was passed through a passage into the after burning section where more air was added in the presence of another burner in an attempt to burn off the smoke.

For the burning of paper and cardboard the system was partially successful. However, where the waste contained more than 2-3% plastics considerable quantities of smoke were emitted. As a great amount of air was still used the "flyash" content remained high.

To limit the amount of smoke and "flyash" emitted, wet scrubbers or water traps, larger after burning chambers and refractory filter blocks were used.

There was however an increased risk of damage to refractory filters caused by loading abuse and over enthusiastic cleaning, performance on high plastic content waste was not good. The principal disadvantage however was that they were expensive to run and maintain.

The development of the new incineration system in the early 1960s was in two stages. The immediate problem was to eliminate the polluting effect of incineration and later with increases in energy costs to utilize the energy generated, thereby reducing fuel consumption.

Three factors were highlighted as the causes of emission pollution. They were:

a) "Flyash" was caused by the driving of large amounts of air through the waste to cause efficient burning.

b) Smoke was primarily caused by the rapid volatilzation of plastic or organic matter, combined with poor mixing in the after-burning chamber.

c) Overloading of the incinerator caused the rate of burning to exceed the available combustion air supply causing smoke.

A way was also sought to eliminate danger to the operator. The result is shown in figure 4.

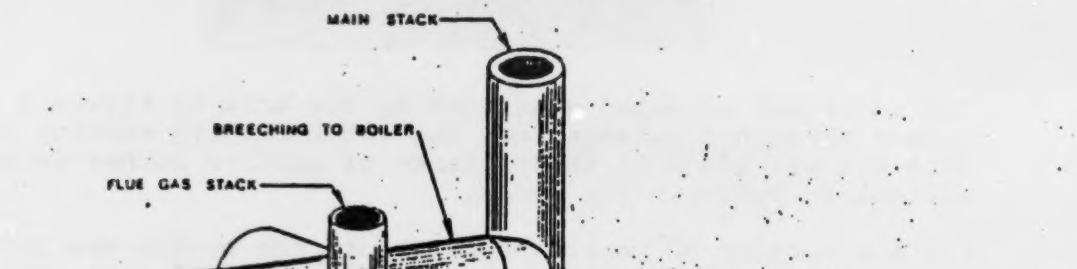

MAIN STACK
BREECHING TO BOILER
FLUE GAS STACK
SECONDARY CHAMBER
INCINERATOR
PRIMARY CHAMBER
CONTROL PANEL
REFRACTORED GUILLOTINE DOOR
CHARGING OPENING
RAM LOADER
INDUCED DRAFT FAN
HEAT RECOVERY BOILER

Fig.4

The formula chosen was to have two burning chambers. In the first, only a small amount of combustion air was admitted, causing only partial burning of the waste. The smoke and gases produced percolated upward through the waste-bed into the second chamber, leaving volatile matter in the waste-bed. The first chamber used only about one-sixteenth of the amount of air used in the primary chamber of conventional incinerators and the velocity of gases leaving the firebed was extremely low, less than 0.3m per second. The result is that the waste was thermally decomposed under "calm" or "acquiescent" conditions leaving a sterile ash residue.

The gases entering the second (upper) chamber from the first chamber consisted of carbon particles (smoke), hydrogen, methane, carbon monoxide, basic monomers, carbon dioxide and water vapor, in proportions which effectively made it an acceptable fuel gas for the secondary chamber. These gases were burned in a high intensity after-burning chamber. As there was little or no "flyash" this chamber burned turbulently as air and gases were mixed. This system is capable of burning 100% plastics continuously without smoke.

The classic grate was dispensed with and the waste was loaded onto and burned on a flat refractory hearth.

A specially designed air entry system prevented air inlets under the waste becoming blocked. Chimney stack emissions were low and the incinerator proved capable of smokeless operation, even when operating on widely varying types of waste.

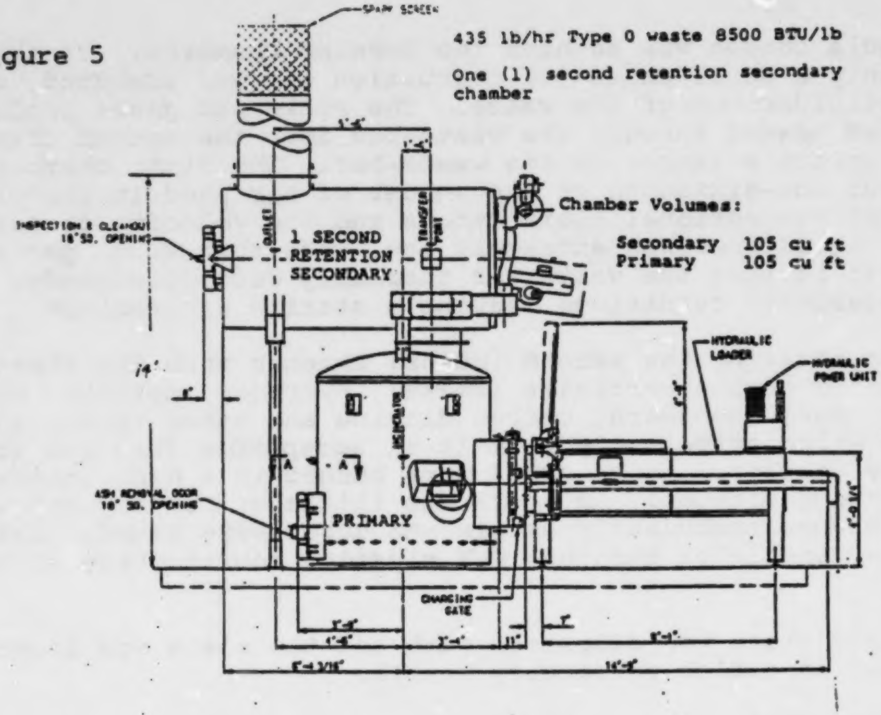
Using an automatic ram loader it was possible to avoid overloading and to eliminate operator risk when loading.

The burning rate of the system is commensurate with the loading rate when the system is fully operational.

Having achieved temperatures of 1600°F in burning the gases emitted from the primary chamber, the heat generated can be used to generate steam and hot water for use by hospitals and industry. This is achieved by the hot emission from the incinerator being passed through a specially designed heat recovery boiler where hot water and steam are produced.

Figure 5 indicates a modern, 500 lb/hr, packaged, controlled air incinerator system, capable of burning high and low heat release waste. One and two second retention secondary chambers are indicated, operating temperatures 1800°F to 2000°F modulated fuel-air, with cubic footage of both chambers shown. Obtainable particulate emissions would be the Federal regulation of 0.08 without gas scrubbing.

Figure 5



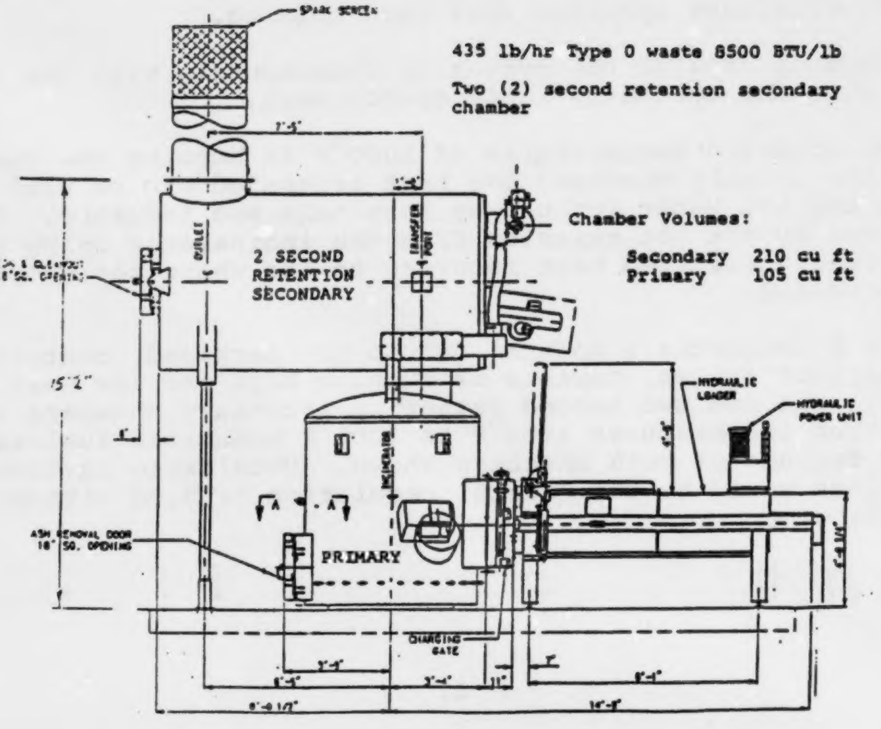
435 lb/hr Type 0 waste 8500 BTU/lb

One (1) second retention secondary chamber

Chamber Volumes:

Secondary 105 cu ft
Primary 105 cu ft

SPARK SCREEN
INSPECTION & CLEANOUT 18" SQ. OPENING
OUTLET
1 SECOND RETENTION SECONDARY
TRANSFER PORT
14'
HYDRAULIC LOADER
HYDRAULIC POWER UNIT
INCINERATOR
A A
ASH REMOVAL DOOR 18" SQ. OPENING
PRIMARY
CHARGING GATE
3'-4"
11"
14'-9"



435 lb/hr Type 0 waste 8500 BTU/lb

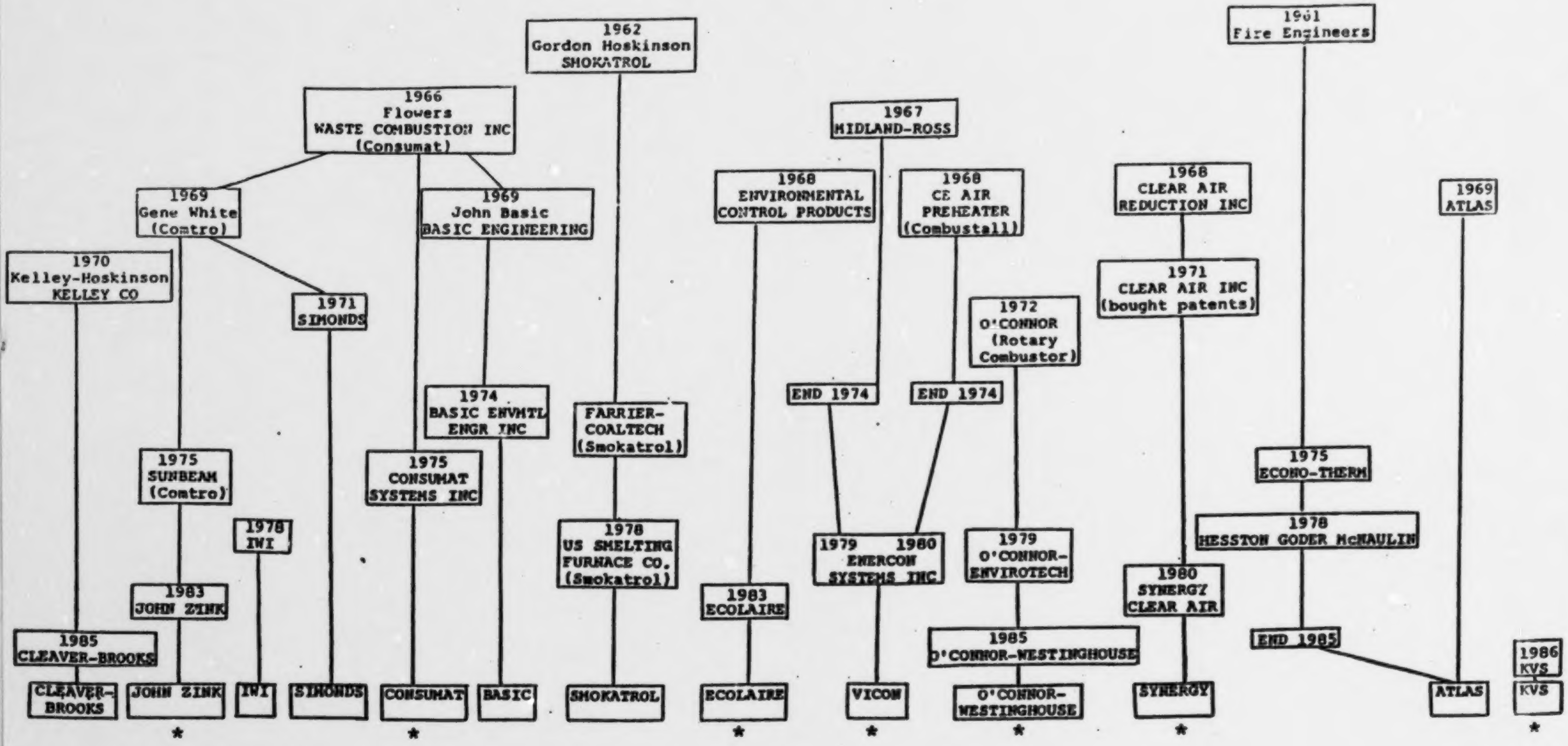
Two (2) second retention secondary chamber

Chamber Volumes:

Secondary 210 cu ft
Primary 105 cu ft

SPARK SCREEN
7'-5"
INSPECTION & CLEANOUT 18" SQ. OPENING
OUTLET
2 SECOND RETENTION SECONDARY
TRANSFER PORT
15'2"
HYDRAULIC LOADER
HYDRAULIC POWER UNIT
INCINERATOR
A A
ASH REMOVAL DOOR 18" SQ. OPENING
PRIMARY
CHARGING GATE
3'-4"
11"
14'-9"

DEVELOPMENT OF THE SMALL SCALE, FACTORY PACKAGED, INCINERATOR INDUSTRY


1962 Gordon Hoskinson SHOKATROL
1961 Fire Engineers
1966 Flowers WASTE COMBUSTION INC (Consumat)
1967 MIDLAND-ROSS
1969 Gene White (Comtro)
1969 John Basic BASIC ENGINEERING
1968 ENVIRONMENTAL CONTROL PRODUCTS
1968 CE AIR PREHEATER (Combustall)
1968 CLEAR AIR REDUCTION INC
1969 ATLAS
1970 Kelley-Hoskinson KELLEY CO
1971 SIMONDS
1971 CLEAR AIR INC (bought patents)
1972 O'CONNOR (Rotary Combustor)
END 1974
END 1974
1974 BASIC ENVMTL ENGR INC
FARRIER-COALTECH (Smokatrol)
1975 SUNBEAM (Comtro)
1975 CONSUMAT SYSTEMS INC
1975 ECONO-THERM
1978 IWI
1978 US SMELTING FURNACE CO. (Smokatrol)
1979 1980 ENERCON SYSTEMS INC
1979 O'CONNOR-ENVIROTECH
1978 HESSTON GODER McNAULIN
1980 SYNERGY CLEAR AIR
1983 JOHN ZINK
1983 ECOLAIRE
1985 CLEAVER-BROOKS
1985 O'CONNOR-WESTINGHOUSE
END 1985
1986 KVS
CLEAVER-BROOKS
JOHN ZINK *
IWI
SIMONDS
CONSUMAT *
BASIC
SHOKATROL
ECOLAIRE *
VICON *
O'CONNOR-WESTINGHOUSE *
SYNERGY *
ATLAS
KVS *

* With MSW capabilities

Source: Chronological data researched and compiled in April 1988 by Gene White

CONTROLLED AIR INCINERATION
FOR
BIOHAZARDOUS WASTE
"TECHNOLOGY AND REGULATORY ECONOMIC IMPACTS"

Presented by

Steve Shuler

at the

Hospital Waste Incineration & Hospital Waste Sterilizers Workshop

San Francisco, CA - May 10-12, 1988

Baltimore, MD - May 24-26, 1988

JOY ECOLAIRE
COMBUSTION PRODUCTS, INC.
A Joy Technologies Company

P. O. Box 240707
11100 Nations Ford Road
Charlotte, NC 28224
Phone (704) 588-1620
Telex 572-549
Fax (704) 588-5903

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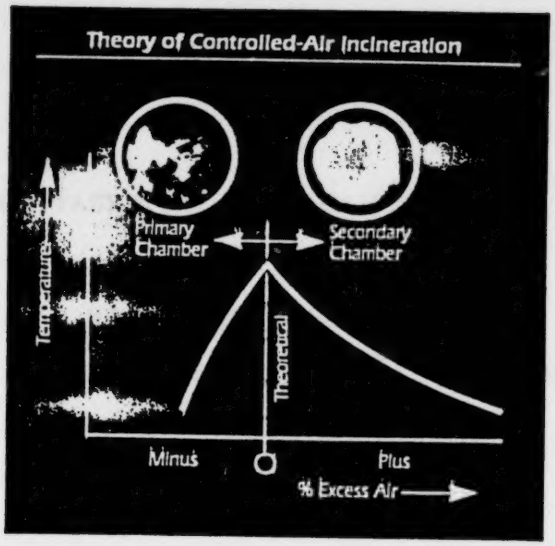
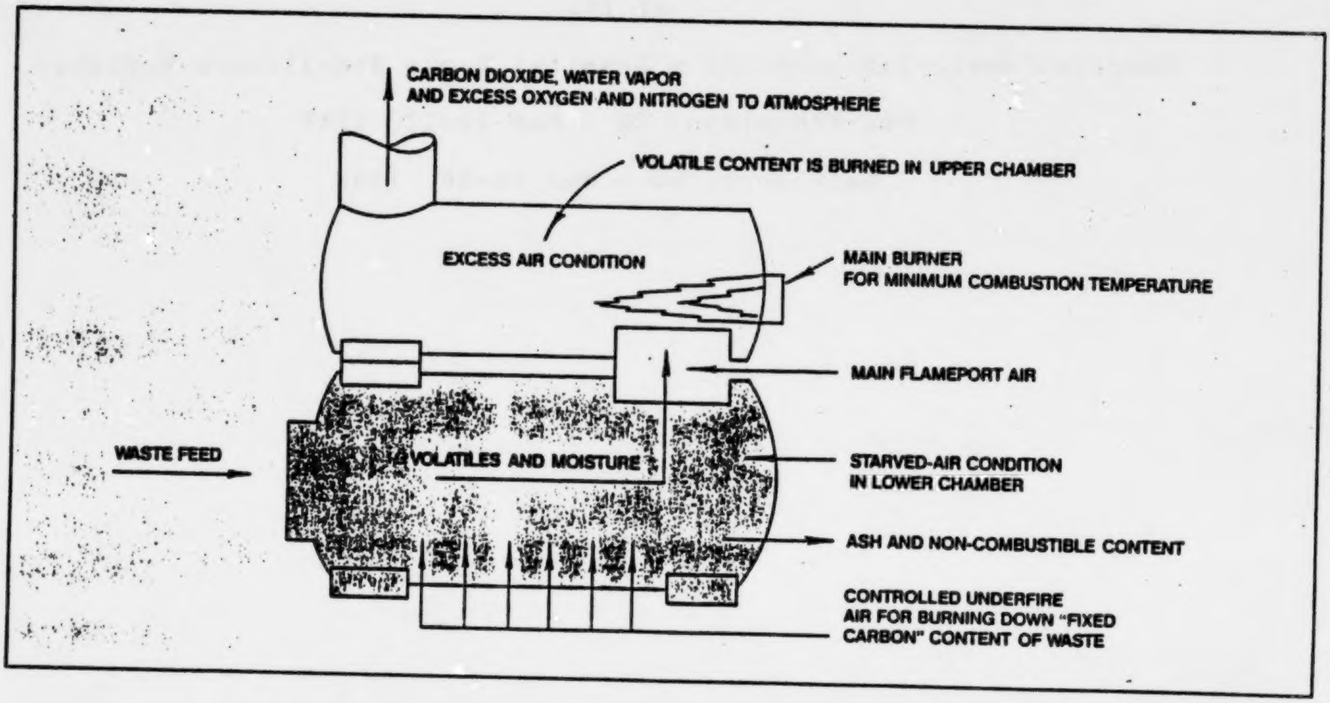
CONTROLLED AIR INCINERATION




CARBON DIOXIDE, WATER VAPOR AND EXCESS OXYGEN AND NITROGEN TO ATMOSPHERE
VOLATILE CONTENT IS BURNED IN UPPER CHAMBER
EXCESS AIR CONDITION
MAIN BURNER FOR MINIMUM COMBUSTION TEMPERATURE
MAIN FLAMEPORT AIR
WASTE FEED
VOLATILES AND MOISTURE
STARVED-AIR CONDITION IN LOWER CHAMBER
ASH AND NON-COMBUSTIBLE CONTENT
CONTROLLED UNDERFIRE AIR FOR BURNING DOWN "FIXED CARBON" CONTENT OF WASTE

JOY®
ECOLAIRE
COMBUSTION PRODUCTS, INC.
A Joy Technologies Company

Open burning, commonly referred to as the first incinerator, contains features which modern incineration systems are designed to control during the combustion process, i.e., starved air, excess air, volatiles, and ash. As shown in the preceding graph, the primary combustion chamber is designed to operate in an oxygen deficient atmosphere; whereas, the secondary combustion chamber operates in an oxygen rich atmosphere. Objective operational results are to achieve maximum burn-out (minimal fixed carbon in the ash), minimal particulate emissions, and maximum destruction efficiency while consuming minimal fossil fuel to maintain operating temperatures.

The principle of controlled air modular incineration systems is to precisely control the combustion air within the primary combustion chamber which also enables precise control of the temperature and rate of volatization of the waste. The basis of this is defined as "less than theoretical air" which results in the formation of a mixture of dense smoke and combustible organic vapors. Further, operation of the primary combustion chamber in this manner results in non-turbulent conditions with minimal ash carry-over.

Theoretical combustion air is the precise amount of air required for complete combustion and is otherwise known as "stoichiometric" air. The secondary combustion chamber is designed to operate with precisely controlled excess combustion air which also achieves maximum turbulent mixing with the dense smoke and combustible organic vapors originating from the primary combustion chamber to attain complete combustion and maximum destruction efficiency of toxic materials while also maintaining operating set point temperatures with minimal fossil fuel input. Typical operating temperatures are in the range of 1400-1600° F for the primary combustion chamber and 1800-2000° F for the secondary combustion chamber.

Waste chemistry is represented by the following:

Carbon (C)
Hydrogen (H)
Oxygen (O)
Moisture
Inorganics

with traces of:

Nitrogen (N)
Sulfur (S)
Chlorine (Cl)

Combustion reactions are:

$$C + O_2 \xrightarrow{\Delta} CO_2$$

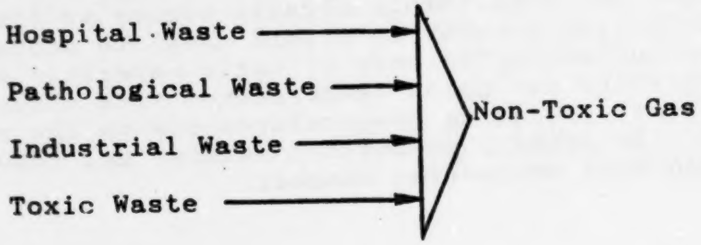
$$H + 1/2\ O_2 \xrightarrow{\Delta} H_2O$$

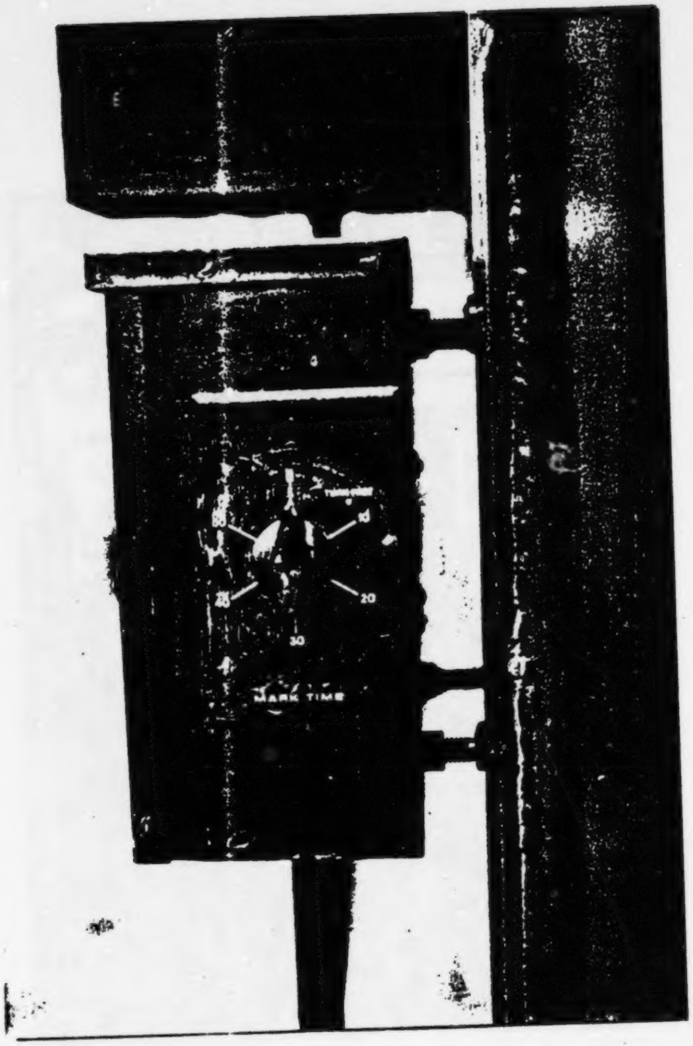
$$O \xrightarrow{\Delta} \text{Unchanged}$$

$$\text{Moisture} \xrightarrow{\Delta} \text{Unchanged}$$

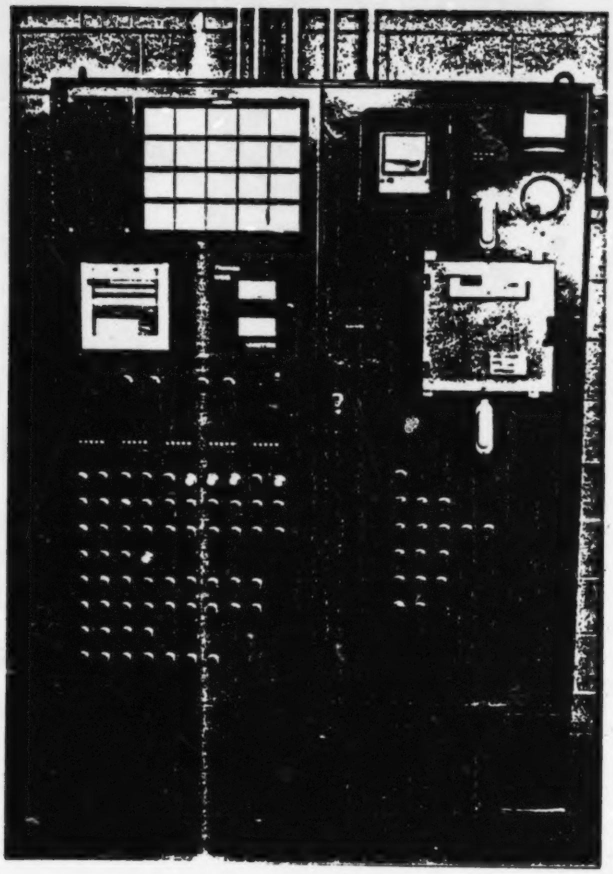
$$\text{Inorganics} \xrightarrow{\Delta} \text{Ash}$$

These reactions of combustion summarize as follows:

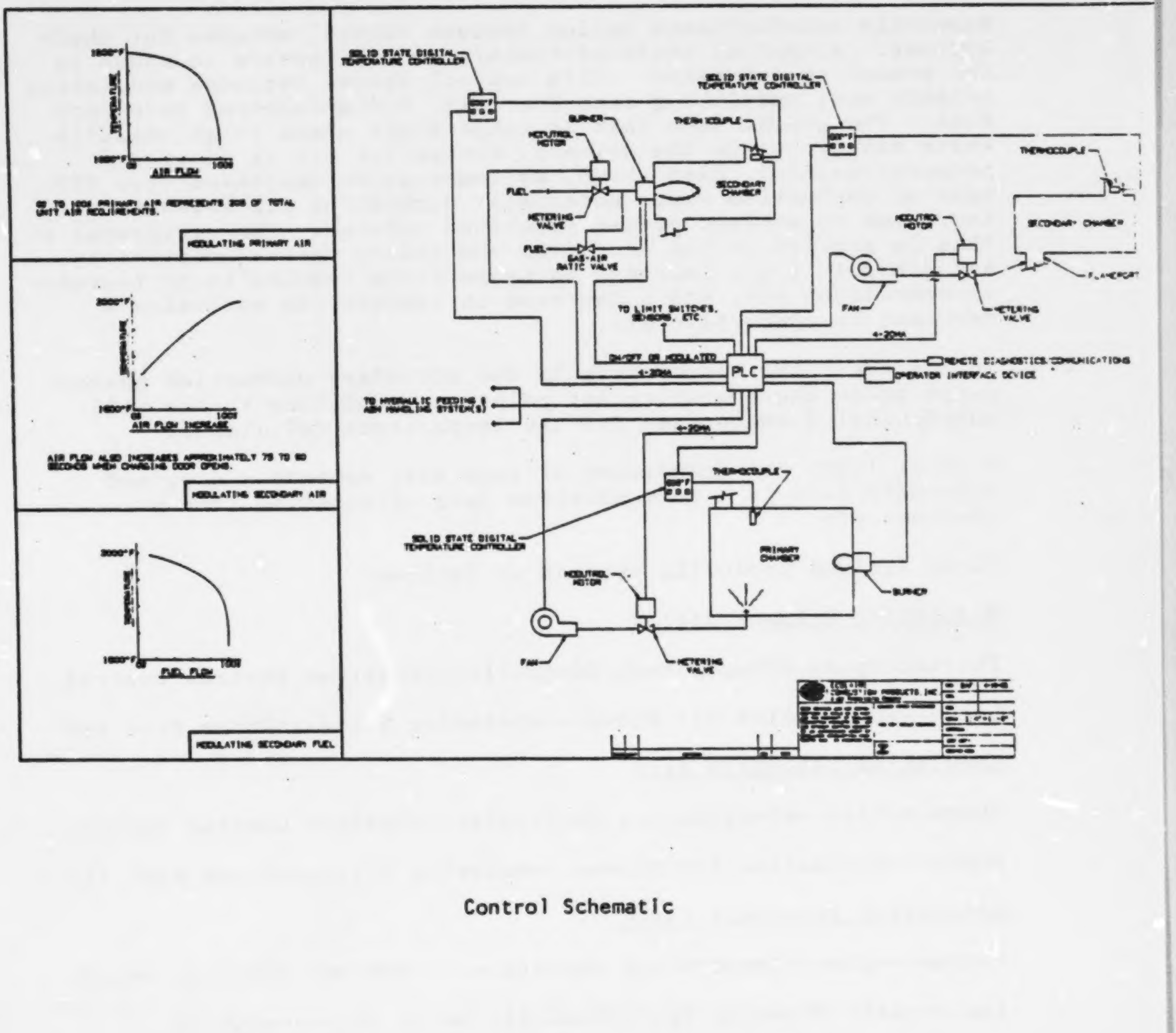

Hospital Waste
Pathological Waste
Industrial Waste
Toxic Waste
Non-Toxic Gas


20
30
MARK TIME

Control System furnished by small "Mom & Pop" firms



Modern electronic control cabinet


1800°F
TEMPERATURE
1600°F
0%
100%
AIR FLOW
0% TO 100% PRIMARY AIR REPRESENTS 20% OF TOTAL UNIT AIR REQUIREMENTS.
MODULATING PRIMARY AIR
2000°F
TEMPERATURE
1600°F
0%
100%
AIR FLOW INCREASE
AIR FLOW ALSO INCREASES APPROXIMATELY 75 TO 90 SECONDS WHEN CHARGING DOOR OPENS.
MODULATING SECONDARY AIR
2000°F
TEMPERATURE
1600°F
0%
100%
FUEL FLOW
MODULATING SECONDARY FUEL
SOLID STATE DIGITAL TEMPERATURE CONTROLLER
BURNER
MODUTROL MOTOR
FUEL
METERING VALVE
FUEL
GAS-AIR RATIO VALVE
THERMOCOUPLE
SECONDARY CHAMBER
SOLID STATE DIGITAL TEMPERATURE CONTROLLER
THERMOCOUPLE
SECONDARY CHAMBER
MODUTROL MOTOR
FLAMEPORT
FAN
METERING VALVE
TO LIMIT SWITCHES, SENSORS, ETC.
4-20MA
ON/OFF OR MODULATED
4-20MA
PLC
REMOTE DIAGNOSTICS/COMMUNICATIONS
OPERATOR INTERFACE DEVICE
TO HYDRAULIC FEEDING & ASH HANDLING SYSTEM(S)
4-20MA
THERMOCOUPLE
SOLID STATE DIGITAL TEMPERATURE CONTROLLER
PRIMARY CHAMBER
BURNER
MODUTROL MOTOR
FAN
METERING VALVE
COMBUSTION PRODUCTS, INC.

Control Schematic

Although most regional "Mom & Pop" incinerator fabricators have been forced to either upgrade their technology or go out of business, we still have a number of these systems being sold. Controls for these systems are typically not much more than a timer as depicted in the preceding photograph. Modern incineration systems, however, employ complete control logic for all operating elements of the system, including alarms and automatic shut-down when systems malfunction or begin to operate outside set point control parameters.

Reputable manufacturers employ various control schemes for their systems. A typical state-of-the-art control system is shown in the preceding schematic. This control scheme includes modulating primary air, modulating secondary air, and modulating secondary fuel. The graphs show that as temperature rises (high volatile waste materials) in the primary, combustion air is decreased proportionately. Also shown, as temperature decreases (low BTU heat of combustion waste materials) combustion air automatically increases to achieve proper volatiles release. The reciprocal of this is applied to the secondary combustion chamber modulating air control; i.e., increase in temperature results in an increase in combustion air, and a decrease in temperature activates a decrease in combustion air.

In the event the temperature in the secondary combustion chamber drops below the operating set point, a modulating burner will automatically compensate for the temperature deficiency.

Control logic for modulating primary air, secondary air, and secondary fuel is a communication loop originating from a thermocouple.

These systems typically operate as follows:

Modulating Primary Air:

Thermocouple-->Temperature Controller-->Systems Central Control

Logic-->Combustion Air Blower-->Metering Valve-->Under Fire Air

Modulating Secondary Air:

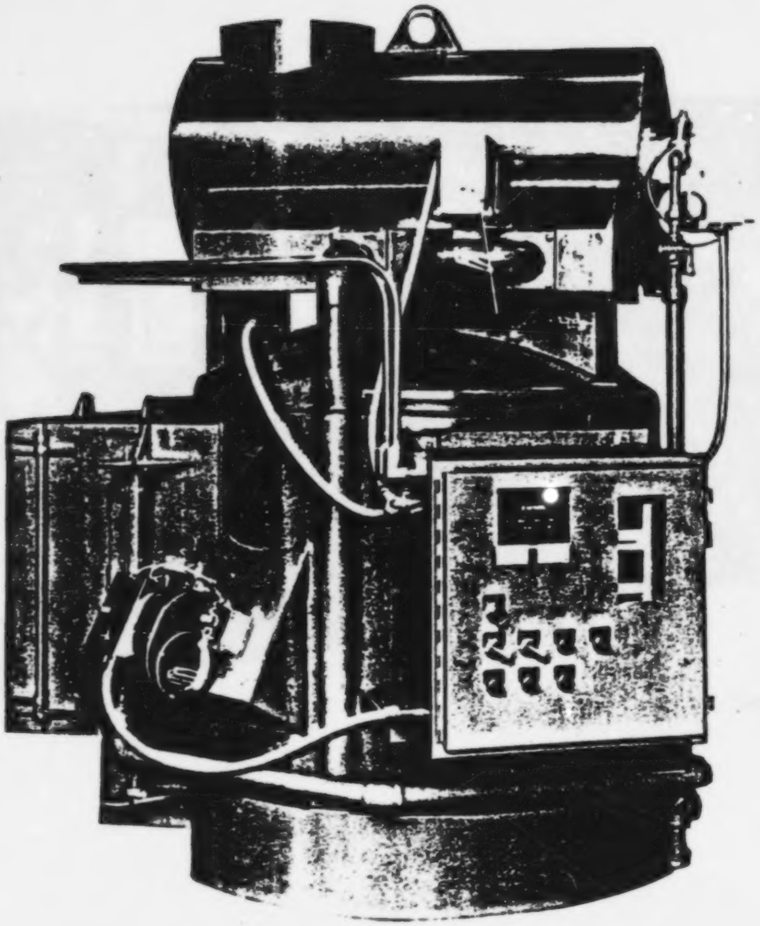
Thermocouple-->Temperature Controller-->Systems Central Control

Logic-->Combustion Air Blower-->Metering Valve-->Flame Port Air

Modulating Secondary Fuel:

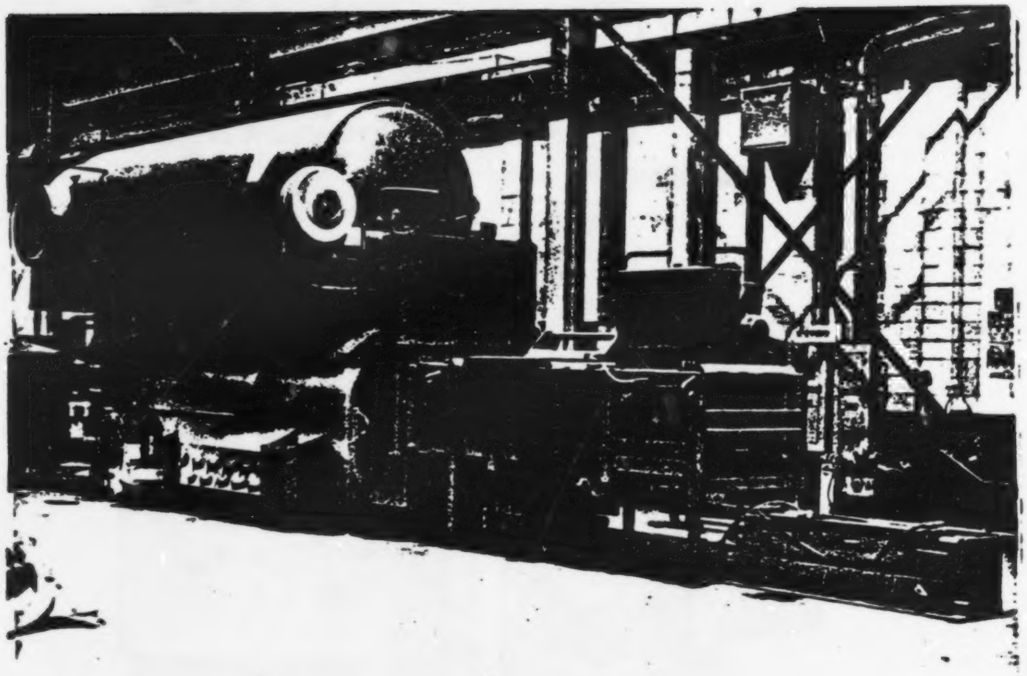
Thermocouple-->Temperature Controller-->Systems Central Control

Logic-->Air Metering Valve/Fuel-Air Ratio Valve-->Burner



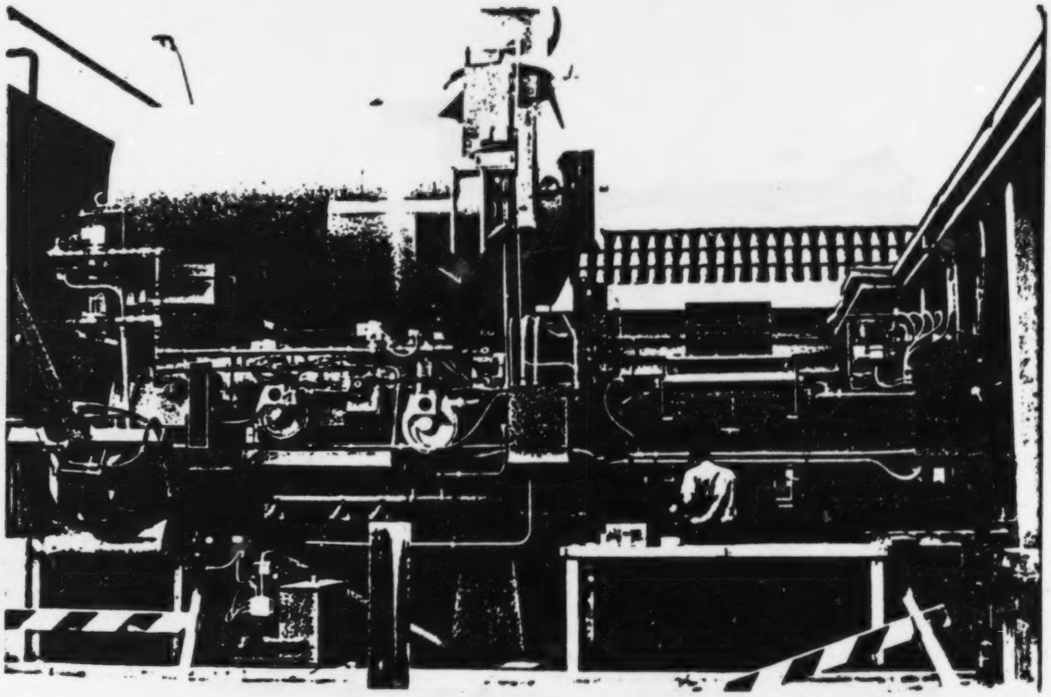
Small, Manually Operated Incineration System

* (8) Hr./Day design duty



Modern Incineration System - factory assembled

- *10-12 Hr/Day Design Duty
- *Feeder
- *Internal Ash Ram
- *2-second Retention Secondary Combustion Chamber
- *Energy Shrouds



Modern Continuous Duty Incineration System

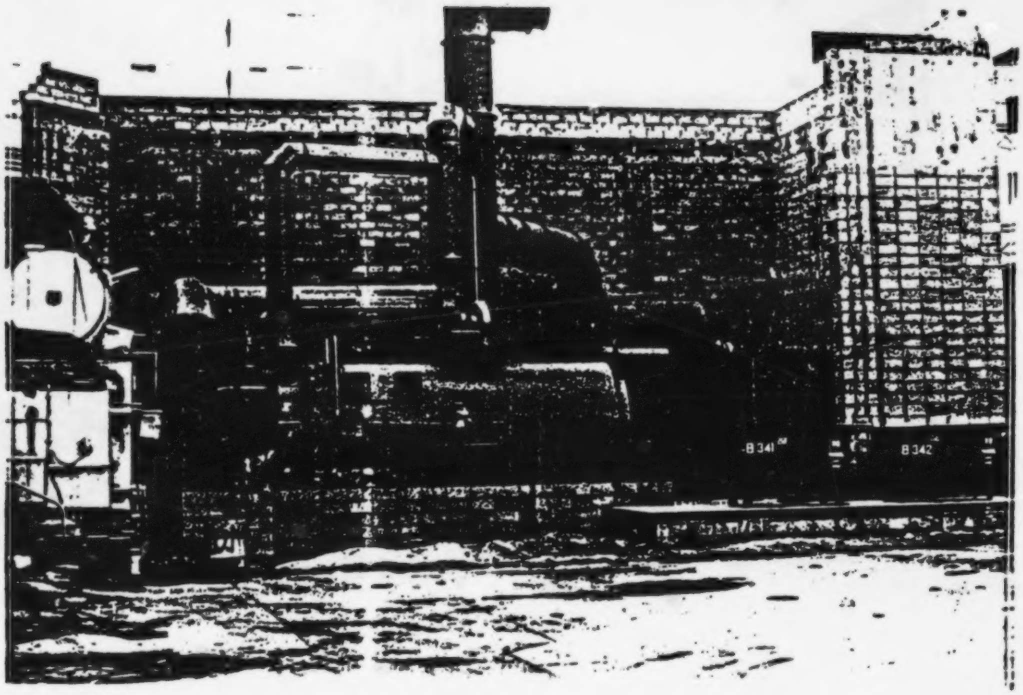
*Under Construction

*Ram Feeder

*Internal Ash Ram

*Automatic Ash Removal

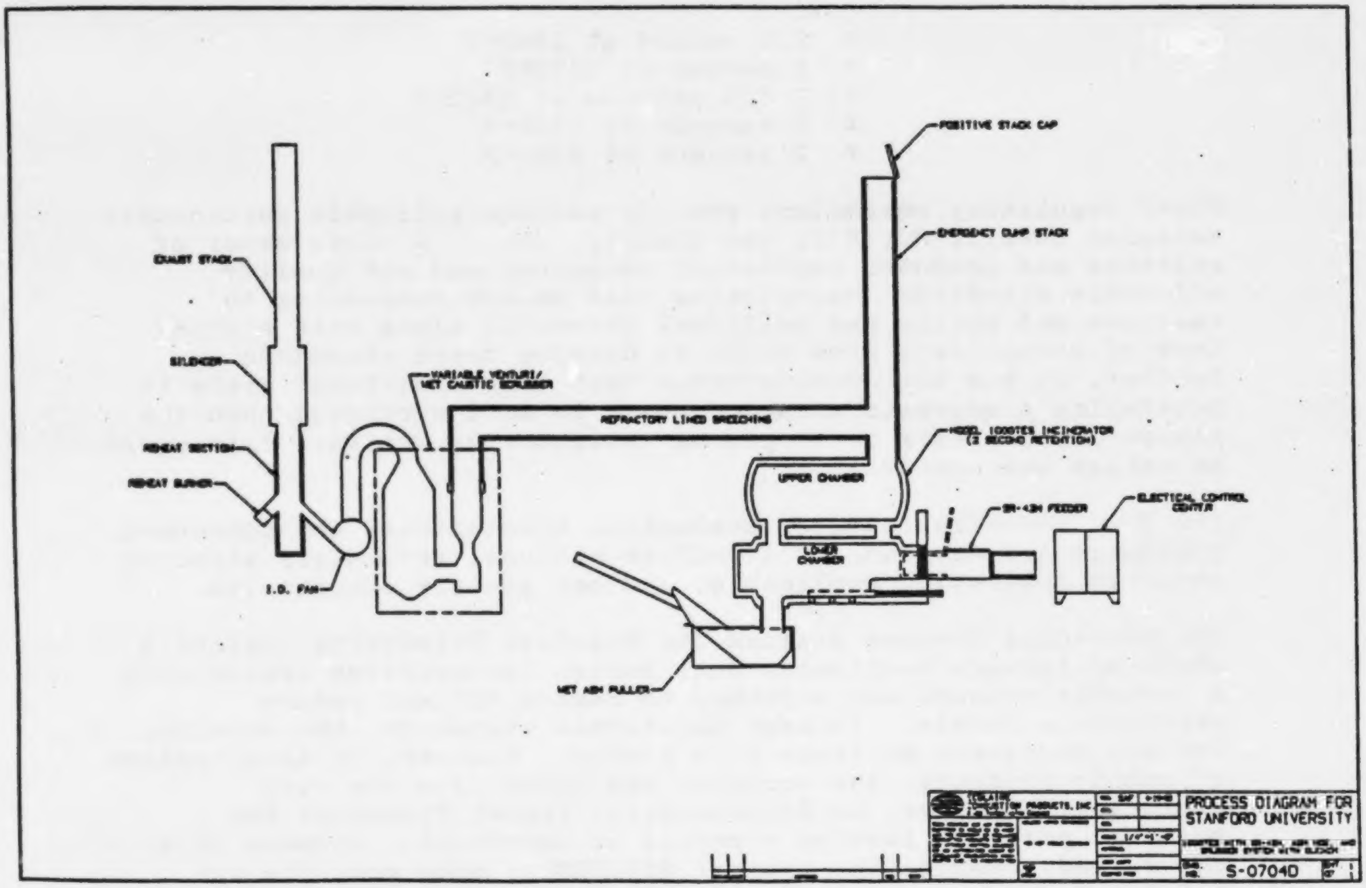
*Burn Only Application



Modern, Continuous Duty Incineration System

- *Under Construction
- *Continuous Feeder with Cart Dumper
- *Internal Ash Ram
- *Automatic Ash Removal
- *Waste Heat Recovery Boiler

Note: Old, Decommissioned Incinerator on left


POSITIVE STACK CAP
EMERGENCY DUMP STACK
EXHAUST STACK
SILENCER
VARIABLE VENTURI/ WET CAUSTIC SCRUBBER
REFRACTORY LINED BREECHING
MODEL 1000TES INCINERATOR (2 SECOND RETENTION)
REHEAT SECTION
UPPER CHAMBER
REHEAT BURNER
SR-434 FEEDER
ELECTICAL CONTROL CENTER
LOWER CHAMBER
I.D. FAN
WET ASH PULLER
PRODUCTS, INC.
PROCESS DIAGRAM FOR STANFORD UNIVERSITY
S-0704D

In the preceding photographs systems are shown which range from very simple manually operated incinerators to very complex continuous duty installations with continuous feeders, automatic ash removal, and waste heat recovery boilers. All of these systems have one common feature, a large secondary combustion chamber.

Today's regulatory trend is to require a specified retention time in the secondary combustion chamber at a given temperature. Typically these are:

- 1/2 second at 1800° F
- 1 second at 1800° F
- 1 1/2 seconds at 1800° F
- 2 seconds at 1800° F
- 2 seconds at 2000° F

Other regulatory parameters specify maximum allowable particulate emission levels, CO, HCl, ash quality, etc.. A close study of existing and proposed regulatory emissions and ash quality allowable standards demonstrates that we are responding to emotions and public and political pressure, along with a gross lack of actual data from which to develop these standards. Further, it has been demonstrated that each individual state is developing a separate standard which is more stringent than the standard previously developed by neighboring states. This could be called one-upmanship.

The EPA, industry leaders, combustion specialists, and concerned consumers are desirous of a uniform national regulatory standard which is realistic, applicable, and not grossly exaggerated.

The preceding process diagram for Stanford University depicts a state-of-the-art continuous duty design incineration system with a variable venturi wet scrubber to remove HCl and reduce particulate levels. To meet California standards, the scrubber was not necessary as tests have proven. However, in anticipation of public pressure, the scrubber was added from the very beginning. Further, an Environmental Impact Statement was required prior to issuing a permit to construct. Perhaps this is not so bad, despite the typical $50,000 or more cost for an E.I.S.. However, once sufficient data has been established, should this requirement not be dropped to avoid the cost of generating a redundant document on each new application to construct?

Proposed regulations in some instances now require air pollution control devices which do not yet exist -- at any price. Surely they can be invented, but who can afford them? Further, the big question is "Are they really necessary?" The best example was provided recently by a combustion/air pollution expert who equated a proposed regulatory standard as requiring scrubbing the exhaust gases sufficiently clean to equate the allowable emission to be the size of one postage stamp per cubic mile.

Following is a summary of the capital and operating cost impact in which various current and proposed regulatory standards are requiring. These cover the monitoring and recording devices for various pollutants and two scrubbing technologies.

Despite the superior designs a given manufacturer may execute in his incineration equipment product line, the key element in a successful operation is the human operator. It is not uncommon for an institution to install a system with an installed cost of $1,000,000 or more and assign the lowest paid wage individual as the system operator. The manufacturer will perform the complete task of training this individual; however, this is not the worker's focus. Thus, a bad system will frequently result from operating parameters being changed for the benefit of someone who could care less. We, as an industry, promote establishing a national regulatory requirement for operator and supervision training certification.

STACK GAS MONITORS

Types and Application

In-Situ:

- Probe Attached Gas Analyzer
- Analysis Inside Stack

Ex-Situ:

- High Temperature and/or Very Dirty and Wet Flue Gas
- Analysis Outside Stack
- Sample Pulled Through Heat-Traced Line into Container to Monitors

Extractive:

- High Temperature and/or Very Dirty and Wet Flue Gas
- Analysis Outside Stack
- Sample Pulled Through Heat-Traced Line into Air Conditioned Building or Cabinet to Extractive Monitors
- Sample Chilled and Filtered for H_2O Removal
- Can Sequence Between (2) or More Sources
- Sequences Backpurge, Calibration, and Sample Intervals with Separate Lines to Each Probe

GAS MONITOR CERTIFICATION

- EPA TESTING PROTOCOL
- PROOF OF ACCURACY
- When measuring SO_2, NOX, and CO, guidelines are to correct for Dilution Air to a specified standard; i.e. 10% O_2 or 3% CO_2

STACK GAS SCRUBBER

Project Cost Impact

- Waste at 8500 BTU/lb
- Retention 2-seconds at 1800°F
- 3 58 SCFM Dry Flue Gas

I - Variable Venturi Wet Scrubber:

Incinerator Waste Burn Rate (lb/hr)	Flue Gas (SCFM)	Scrubber $ w/o Boiler	Scrubber $ w/ Boiler
415	1,500	$ 60,000	$ 50,000
550	2,000	85,000	60,000
695	2,500	98,000	73,000
835	3,000	113,000	85,000
1,110	4,000	128,000	97,000
1,395	5,000	145,000	112,000
1,675	6,000	170,000	128,000
2,230	8,000	195,000	150,000
2,790	10,000	235,000	190,000
3,350	11,000	280,000	230,000

- Venturi Operating Pressure: 30 In. H_2O

- Particulate Size:

  10% Less than 1/2 micron(s)
  20% Less than 1 micron(s)
  55% Less than 3 micron(s)
  80% Less than 6 micron(s)

- Application Operating Range:

  0.03 G/DSCF Corrected to 7% O_2
  95% HCl Removal or (50) PPM
  70% SO_2 Removal or (30) PPM
  Removal of Condensation of Heavy Metals

- Texas Test Result

  0.0179 G/DSCF Front and Back Half, Uncorrected
  25 PPM HCl
  Less than (5) PPM VOC
  Less than (0.4) PPM Chlorine
  14% Average O_2
  4% CO_2
  180% Excess Air

Note: 1.) Above prices furnished by Anderson 2000 Inc.
2.) Prices do not include installation

STACK GAS SCRUBBER

Project Cost Impact

II - Dry Scrubber/Bag House:

$375,000-$1,000,000

* Minimal economy of scale (10,000 ACFM and Above)
* Most Efficient
* Limited vendors for systems less than (2,700) lb/hr burn rate

Note: Above prices are typical of Interel or Western Precipitation

III - Annual Maintenance/Consumables/Power Consumption:

A) Wet Scrubber:

* Up to 58% of original capital equipment cost

B) Dry Scrubber/Bag House:

* Up to 40% of original capital equipment cost

SESSION II: MANUFACTURERS' PANEL DISCUSSION

SUMMARY OF DISCUSSION (SAN FRANCISCO)

Q: What can regulators do to assist manufacturers?

A: (J. Kidd, Cleaver Brooks) Regulators can:

1) Help define to manufacturers what they want. Regulations that change in mid-stream hurt production.
2) Define how good is good.
3) Define design requirements.
4) Take a proactive stand with the public to explain and review the status of activities.

Q: What kind of standards would manufacturers like to see?

A: (J. Kidd, Cleaver Brooks) There are many, but two important areas are training and qualifications, and design requirements. 1800° F is very near 1000° C; it can be arbitrary. It makes no difference to manufacturers.

Q: Does the requirement for a 2 second residence time apply to the secondary chamber only?

A: (J. Kidd, Cleaver Brooks) Yes. It applies from where the gas enters the secondary chamber to the point of exit.

Q: Where is the temperature monitor located?

A: (S. Shuler, Ecolaire Corp.) The point of measurement is between the last introduction of air into the upper chamber, and its exit. How one measures temperature differs by state.

Q: Kansas may be discussing a requirement for 3 seconds at 2000° F.

A: (R. Lee, Consumat Systems Inc.) There is little difference between 1 or 2 seconds residence time. Three seconds complicates matters. One should consider the end result rather than a time value, i.e. what are you trying to achieve? Agencies should encourage manufacturers to help achieve this goal.

(J. Kidd, Cleaver Brooks) Residence time alone does not indicate anything about what happens in combustion which entails time, temperature, and turbulence. Two seconds at 1800° F is good with an inefficient system.

(R. Lee, Consumat Systems Inc.) Consistency of regulations would help rather than the variety now seen state-by-state.

(J. Kidd, Cleaver Brooks) The Waste Combustion Assistance Council, a manufacturers' organization recently formed in Washington, D.C., will probably approach this issue.

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Q: Incinerator operators lack a strong understanding of how the control equipment is put together. APCA is a good vehicle to get the word out. Wages must be high enough so that facilities can keep qualified people. Water treatment and wastewater treatment plant operators have continuous training, to make sure the equipment is run by people who know what they are doing.

Q: What exemptions exist for small facilities?

A: (J. Kidd, Cleaver Brooks) Some states have exemptions for facilities that meet mechanical and process guidelines. Market forces will force many small, exempted facilities to close. From a regulator's standpoint, fewer larger facilities with decent equipment are probably preferable to numerous small incinerators.

Q: There is an ASME Training Committee looking into the issue of operator training. The Committee is made up of regulators, unions, manufacturers, designers, and industry. What constitutes proper training has not yet been determined. This Committee is only considering municipal waste incineration.

Q: What is the cost impact of CEM requirements?

A: (R. Lee, Consumat Systems Inc.) The cost of CEM is prohibitive for smaller units. $300,000-$400,000 for monitoring is not unusual. Smaller units cannot afford to install or maintain CEM.

Q: Please elaborate on the comment that regulators should do a better job of monitoring and enforcement.

A: (J. Kidd, Cleaver Brooks) Regulators must define what type of monitoring is wanted. Continuous temperature monitors are fairly cheap (a couple of thousand dollars). If the right system is present, the right temperature, and the right geometry, CEM with its high costs is unnecessary.

SESSION II: MANUFACTURERS' PANEL DISCUSSION

SUMMARY OF DISCUSSION (BALTMORE)

Q: Water or steam injection have been used to improve ash quality. But water spray can destroy the refractory. How serious is this problem? Shouldn't sprays be used to control temperature, not ash quality?

A: (S. Shuler, Ecolaire Corp.) There was no implication that water should be injected from above for either purpose since the resulting thermal shock does degrade the refractory. Underfire air ports can be used to inject small amounts of steam, not water, in order to fracture slag with thermal shock. Temperature should be regulated by controlling combustion air, not by using water.

Q: In general, how do costs for monitoring equipment compare with total incinerator costs? For example, an 800 lb/hr facility with scrubber, and monitoring for O_2, CO, and opacity.

A: (S. Shuler, Ecolaire Corp.) The total incinerator plant with typical features and options could cost $500,000-$700,000. A wet scrubber system could cost in the same range. A complete set of monitoring equipment could cost $300,000-$400,000. So adding everything related to air pollution can easily double (or even more) the cost of the incinerator.

Q: What would be the costs for the same scenario except with a dry scrubber plus baghouse instead of a wet scrubber?

A: (S. Shuler, Ecolaire Corp.) The cost of the dry scrubber/baghouse could be $375,000-$1 million. Note that systems differ widely in design, life expectancy, and amount of maintenance required. Most such systems are too big for most hospitals: a flow rate of 10,000 cfm, which is small for a dry scrubber/baghouse, implies a charging rate of about 2500 lb/hr.

Q: Can incinerators handling both municipal and infectious waste produce sterile ash without recognizable objects?

A: (J. Gray, Consumat Systems, Inc.) Manufacturers recommend not mixing the two types of waste because infectious waste requires higher temperatures to ensure destruction of pathogens. If an incinerator produces ash with recognizable objects, the charging rate is too high.

Q: How is ash handled within the incinerator?

A: (S. Shuler, Ecolaire Corp.) The ash ram strokes once just before each waste feed, so the burning ash is pushed in pulses toward the ash hopper. To minimize the amount of fixed carbon remaining in the ash, a properly engineered system takes 4-6 hours from charging of waste to the time the ash from that waste enters the quench pit. The pit contains water to cool the ash and to keep uncontrolled air from entering the combustion chamber.

Ash is removed to a disposal container via either a drag chain conveyor or an ash hoe (which works like a backhoe). The waste hauler picks up the container, discharges it to his truck using a front-end loader, and puts the container back.

Q: Is there any exposure of ash to the atmosphere?

A: (S. Shuler, Ecolaire Corp.) Possibly, once the ash is in the disposal container. The volume of ash is 80-85% less than the volume of waste, so the quantity is low, and the frequency of hauling is not high — 2 to 3 times per week. Thus, the ash could be stored for a few days, but typically would be covered.

Q: Facilities accepting boxed waste have a better record of avoiding leaking waste and overfeeding. Ram-fed bags can compress, be ripped, and cause fires on contact with hot incinerator surfaces. Massachusetts may require boxes for waste, though some consider this to be unreasonable.

A: (J. Gray, Consumat Systems, Inc.) Containerization (or lack thereof) of waste is a problem. Ideas are needed in how to handle wastes efficiently and safely. One possibility is development of regional facilities as opposed to an incinerator at each hospital. However, the need to transport waste should also be minimized.

Q: Proper operation requires avoiding excessive air. How can operators be kept from overfeeding air to the primary chamber? What percentage air is recommended?

A: (S. Shuler, Ecolaire Corp.) Operators should not have access to controls for excess air (either positive or negative) Instead, it should be a programmed parameter. A typical desired parameter, based on theoretical considerations, is 80% of stoichiometric air in the primary chamber, and 120% in the secondary.

Q: Complete burnout is important to prevent recognizable objects and minimize fixed carbon in ash. Should there be a standard, e.g. 95% burnout or 5% fixed carbon?

A: (Unidentified speaker) Operator training and design guarantees would be preferable. Improper operation is the main problem. Only adequately educated, technically trained, properly motivated operators can solve problems of unburned waste in ash. Operator certification, and even chief engineer or supervisor certification, are needed.

Q: The Consumat facility discussed in this session used a costly spray dryer and dry scrubber. Why not use air cooling of the flue gas, then dry scrubbing only?

A: (J. Gray, Consumat Systems, Inc.) Both options were considered and the choice was judgmental. Air cooling/dry scrubbing may be best at other facilities.

Q: Can incinerators comply with RCRA if RCRA were to be applied to hospitals?

A: (S. Shuler, Ecolaire Corp.) Volume thresholds apply for RCRA applicability. RCRA control efficiencies cannot be achieved with standard combustion processes, but can be achieved in a proper facility. The permitting process is arduous and its cost can exceed the cost of the incinerator.

SESSION III

SOURCE DATA AND STACK TESTING

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MEASUREMENT of SOURCE EMISSIONS

by

P.K. Leung of Environment Canada

FORWORD

The purpose of this paper is to provide a brief, general discussion on stack testing to those who are not familiar with the subject. Detailed Canadian stack emission data will be presented by my fellow panelist, Mr. Vlado Ozvacic of the Ontario Ministry of Environment (MOE). Later today, Mr. Dave Campbell of Environment Canada will present a paper on the federal government's hospital waste incinerator program.

INTRODUCTION

Sampling for stack emissions from an industrial process involves more than just climbing to the top of a chimney, inserting a probe into the stack and obtaining instantaneous emission data. Prior to the commencement of the actual field testing work, two to three technical experts must spend at least one to two months performing numerous tasks such as:

* setting objectives for the stack testing program
* coordinating with program participants
* performin pre-test quality assurance work on sampling equipment and data logging systems
* preparing, decontaminating, and proofing manual sampling trains
* analyzing reagents for impurities

The pre-test work can be likened to preparing for a mountaineering expedition in which careful planning and meticulous preparation are essential for achieving the ultimate goal — to obtain representative and meaningful emission data.

In designing a source emission survey, a manager must examine the following five important aspects of the testing program:

1. Objectives
2. Target parameters to be measured
3. Sampling and analytical protocols
4. Quality assurance and quality control
5. Resource Requirement

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OBJECTIVES

To assure that the objectives of the programs are understood, the program manager must communicate with all the participants (such as the regulatory agency, the plant operators, the sampling team, and the analytical laboratory). He/she must should set realistic goals for the stack testing program by considering factors such as:

* the resource limitations (PY, $, time)
* the capability, availability, cost, and turn-around time of the source testing team and analytical laboratory
* the end-use of the emission data
* the timing of the program

TARGET PARAMETERS

After establishing the objectives, the manager should make a wish list of target parameters to be measured. A list of candidate target compounds for a stack test may contain:

* Total particulates and selected heavy metals
* Mercury
* Trace organics e.g. dioxins, furans, and PAHs
* Mutagenic substances
* Micro-organisms (survival tests)
* Radioactive elements
* Gases e.g. O_2, CO_2, CO, NO_x, HCl, and non-methane total hydrocarbons

In addition to the stack parameters, the manager should also decide on the process parameters and other samples to be collected during the stack tests. For example:

* Process operating parameters such as temperature and pressure readings, % excess air and pollution control device data
* Feed characteristics (type, heat content, feed rate etc.)
* Ash samples
* Liquid effluent samples

SAMPLING/ANALYTICAL PROTOCOLS

The program manager should contact at least three stack testing consultants for quotes. He/she should obtain references and find out if the stack testing team and the analytical laboratory have previous hand-on experience with the protocols to be used. For compliance testing, it is important that the regulatory agency approves the methods to be used by the consultant, as well as any modifications made to the methods.

The emission samples are usually extracted from ports located high on the stack. In general, a series of three tests is required to determine the average emission rate of each target compound under each set of plant operating conditions. For the 'regular' target compounds such as total particulates, an experienced sampling team may be able to conduct three runs in one day. However, for more 'exotic' compounds such as dioxins, one run (four hours of actual sampling time) per day is the norm. To save time, one may collect a group of compounds having similar chemical characteristics in a single samplng train during each run. However, there are limitations. For example: Samples from the total particulate train (with 5 % aqua-regia solution in the impingers instead of water, see Figure 1) can be analyzed to provide both particulate and heavy metal emission results. However, a MM5 train (see Figure 2) can only provide emission data for trace organics but not for particulates.

Sampling/analytical guidelines or protocols may be obtained from organizations such as NESCAUM, Environment Canada, EPA, Provincial and State regulatory agencies, and ASME. The users of these protocols should be aware that the methodologies for some compounds, such as PAHs, are still in the development stage and that the emission results generated may be of unknown accuracies (as opposite to known precisions).

QUALITY ASSURANCE/QUALITY CONTROL PROGRAMS

It is a common mistake to assume that a QA/QC program is optional and should be implemented only if there is left-over fund from the main testing program. Unfortunately, emission data without adequate QA/QC support are often subject to questioning and difficult to defend. In many cases, the data are considered meaningless and the testing effort wasted. The program manager should reject those testing teams and analytical laboratories that do not already have their own in-house QA/QC programs in place. In compliance testing situations, the manager should also be prepared to accept QA/QC scrutiny from the regulatory agency.

Sampling and analytical QA/QC protocols are usually available from the regulatory agencies. Technical information on QA/QC procedures and data quality objectives can also be found in a joint NESCAUM-EPA publication entitled "Recommended Guidelines for Stack Testing at Municipal Waste Combustion Facilities". The document, compiled by Workgroup members from both the private and public sectors in Canada and US, contains also sampling and analytical methodologies for various trace metals, trace organics, and combustion gases.

RESOURCE REQUIREMENTS

The level of effort required is usually determined by the complexity of the stack testing program. A relatively simple program may involve the measurement of stack emissions by a team of two over a period of three to four days using established sampling techniques, such as the EPA Method 5 (Particulate), at an easily accessible site.

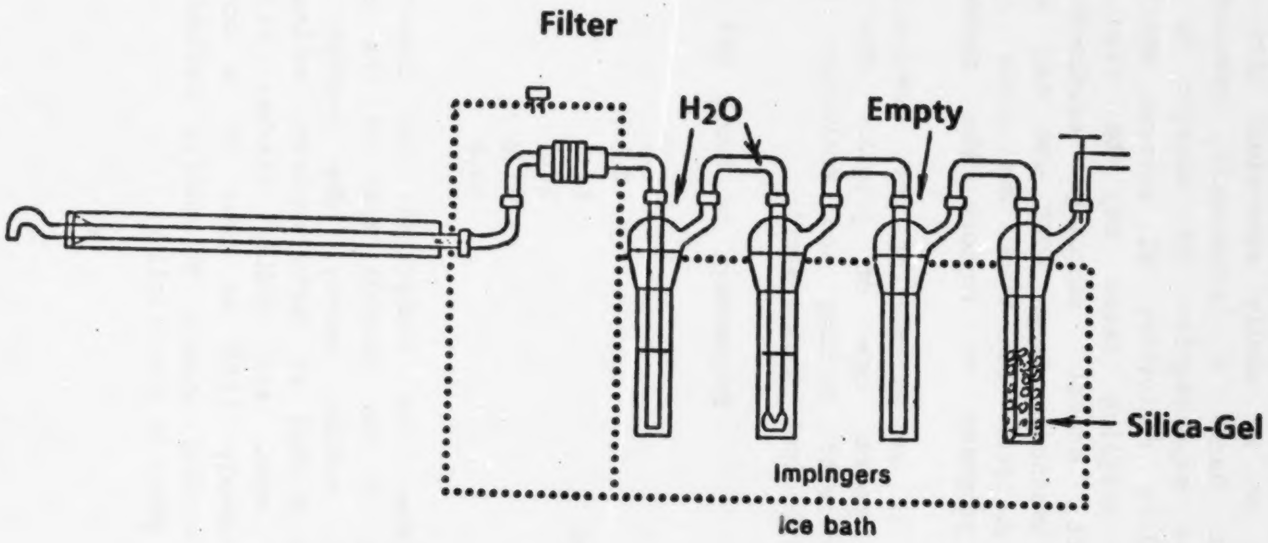
On the other hand, a large-scale research and development type program may require the manager to coordinate simultaneous sampling activities at several stacks and process streams. Each sampling teams may be required to provide state-of-the-art manual sampling equipment for various species of contaminants (e.g. VOST and MM5 sampling trains for trace organics), real-time continuous emission monitors, and QA/QC programs to support the manual and continuous sampling work.

The following is an example of cost break-down for a research and development type of program (Environment Canada's National Incinerator Testing and Evaluation Program at the Quebec City Municipal Incinerator):

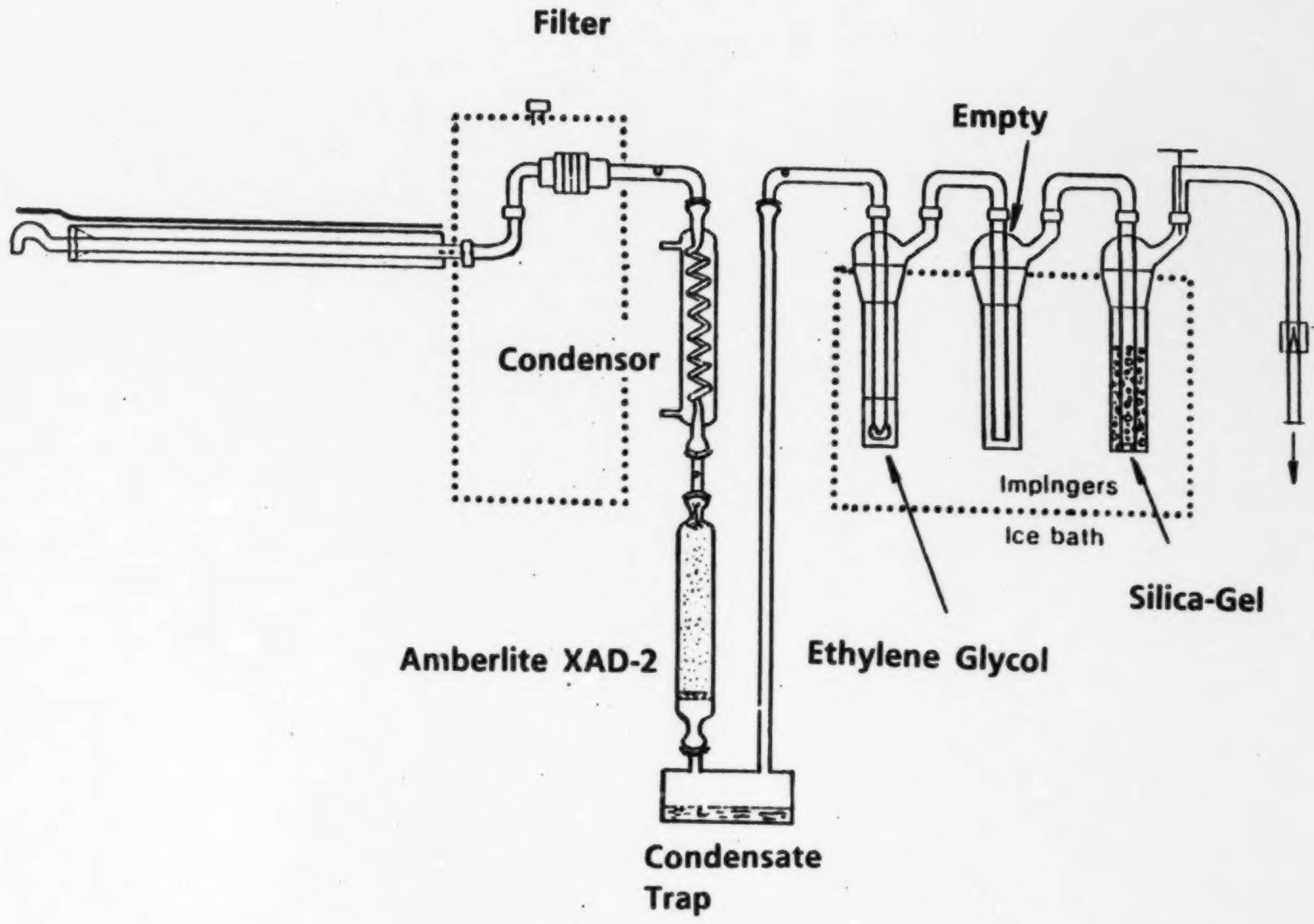
Budget Items	Percentage of total O&M cost
Travel and living	7.3
Equipment rental	8.8
Consumables and misc.	11.0
Chemical analysis	20.9
Non-field labour	21.2
Field labour	30.8

As shown above, the analytical and labour cost contribute significantly to the overall cost of the program. In designing a stack testing survey, the manager should therefore total up the number of tests desired, estimate the labour and analytical cost, and modify his/her wish list accordingly. At approximately $100 an hour for a consultant and $1,000 for each organic sample, scientific curiosity may just have to take second place to practicality.

PARTICULATE / HCl SAMPLING TRAIN


Filter
H2O
Empty
Silica-Gel
Impingers
Ice bath

ORGANIC SAMPLING TRAIN


Filter
Empty
Condensor
Impingers
Ice bath
Silica-Gel
Amberlite XAD-2
Ethylene Glycol
Condensate
Trap

SOURCE DATA AND STACK TESTING IN CALIFORNIA

Gary M. Yee
Air Pollution Specialist
California Air Resources Board

Presented at:

HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP

Golden Gateway Holiday Inn
San Francisco, CA
May 10-12, 1988

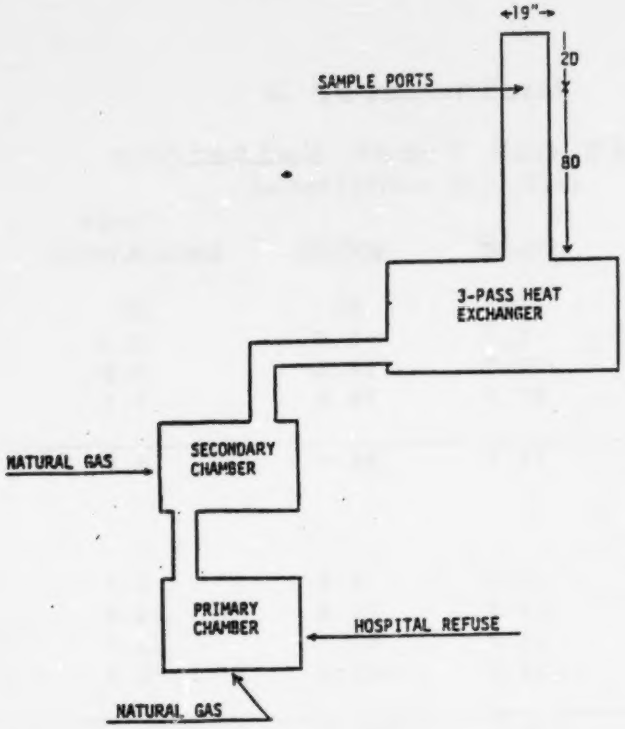
Noncriteria
Pollutant Sampling Methods

Pollutant	Sampling Method
Semi-Volatile Organics	Modified Method 5
Volatile Organics	Bag Sample
Trace Organics	Modified Method 5
HCL	Method 5
Metals	Method 5

Incinerator A
Design and Operating Parameters

Type	2 Chambered Controlled Air
Burners	Primary
	Secondary
Heat Recovery	Boiler /Steam Generation
Emission Controls	None
Combustion Temperature	1100 °F primary
	1800 °F secondary
Waste feed rate	783 lb/hr

INCINERATOR A
Schematic of Hospital Refuse Incinerator
and Sampling Locations


←19"→
20
SAMPLE PORTS
80
3-PASS HEAT EXCHANGER
NATURAL GAS
SECONDARY CHAMBER
PRIMARY CHAMBER
HOSPITAL REFUSE
NATURAL GAS

Incinerator A

Metals, HCL and PM Emissions

	gm/hr	gm/ton
Arsenic	0.04	0.10
Cadmium	0.73	1.87
Chromium (total)	0.11	0.28
Iron	1.81	4.62
Manganese	0.07	0.18
Nickel	0.05	0.13
Lead	9.94	25.40
HCL	6.05 lb/hr	926 ppmv
Particulates	1.91 lb/hr	0.09 gr/dscf

Incinerator A

Dioxin and Furan Emissions

(2,3,7,8) substituted

Dioxins*	ng/m^3	ng/sec	Toxic Equivalence
TCDD	ND	ND	ND
PeCDD	1.9	2.6	2.6
HxCDD	11.7	16.1	0.5
HpCDD	57.7	79.3	2.4
Total	71.3	98.0	5.5
Furans			
TCDF	1.7	2.3	2.3
PeCDF	19.6	26.9	26.9
HxCDF	63.8	87.8	2.6
HpCDF	133.0	183.0	5.5
Total	218.1	300.0	37.3

Incinerator B

Design and Operating Parameters

Type : 2 Chambered Controlled Air

Burners : Primary
: Secondary

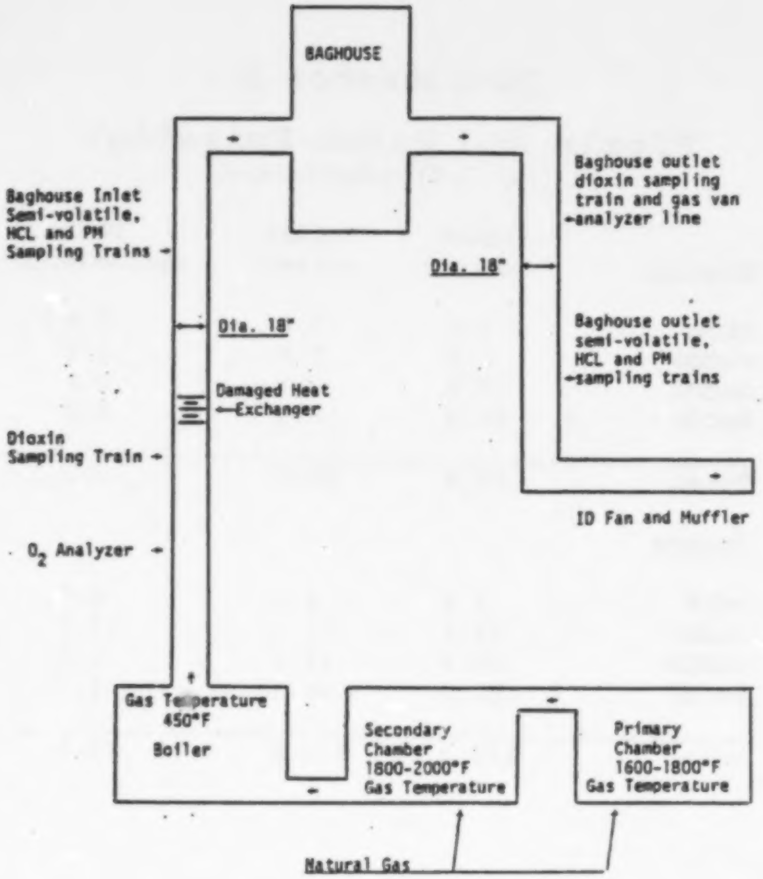
Heat Recovery : Boiler /Steam Generation

Emission Controls : Baghouse

Combustion Temperature : 1600-1800 °F primary
: 1800-2000 °F secondary

Waste feed rate : 980 lb/hr

INCINERATOR B
Schematic of Hospital Refuse
Incinerator and Sampling Locations


BAGHOUSE
Baghouse Inlet
Semi-volatile,
HCL and PM
Sampling Trains
Baghouse outlet
dioxin sampling
train and gas van
analyzer line
Dia. 18"
Dia. 18"
Baghouse outlet
semi-volatile,
HCL and PM
sampling trains
Damaged Heat
Exchanger
Dioxin
Sampling Train
ID Fan and Muffler
O_2 Analyzer
Gas Temperature
450°F
Boiler
Secondary
Chamber
1800-2000°F
Gas Temperature
Primary
Chamber
1600-1800°F
Gas Temperature
Natural Gas

Incinerator B

Metals, HCL and PM Emissions

	gm/hr	gm/ton
Arsenic	0.07	0.14
Cadmium	1.51	3.08
Chromium (total)	0.08	0.16
Iron	1.62	3.31
Manganese	0.10	0.20
Nickel	ND	ND
Lead	12.89	26.31
HCL	7.89 lb/hr	521 ppmv
Particulates	0.05 lb/hr	0.002 gr/dscf

Incinerator B

Dioxin and Furan Emissions

(2,3,7,8) substituted

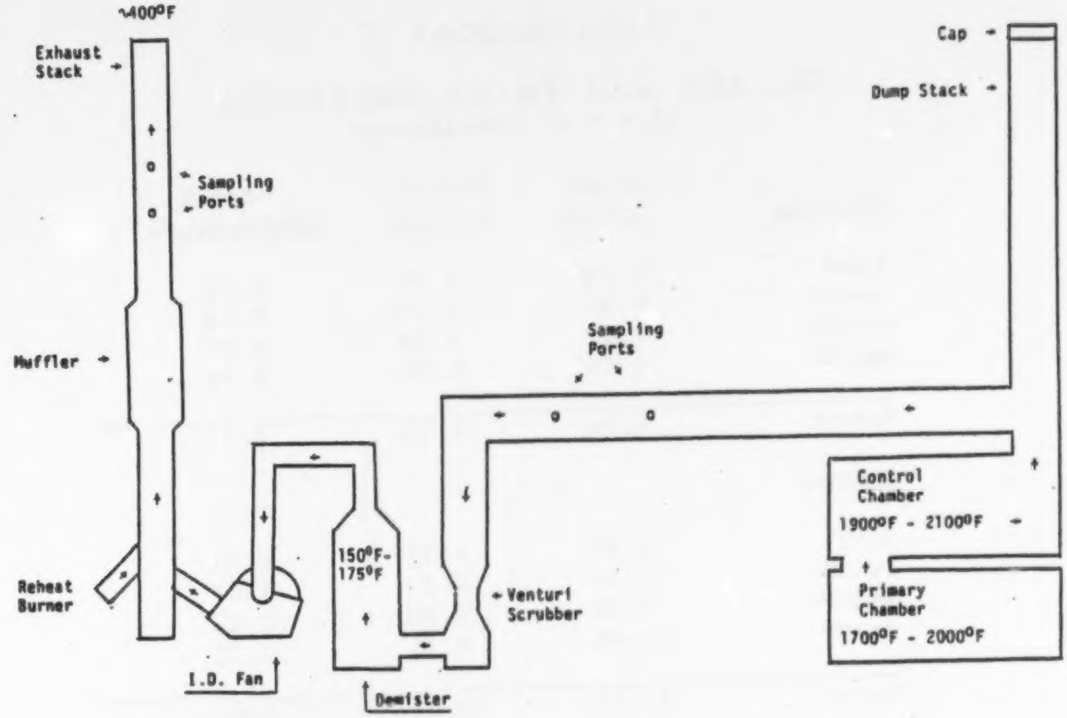
Dioxins	Inlet ng/sec	Outlet ng/sec	Toxic Equivalence
TCDD	0.3	0.4	0.4
PeCDD	1.5	1.8	1.8
HxCDD	9.0	7.4	0.2
HpCDD	44.6	29.6	0.9
Total	55.4	38.8	3.3
Furans			
TCDF	2.1	2.4	2.4
PeCDF	18.1	17.1	17.1
HxCDF	54.4	45.0	1.4
HpCDF	121.2	88.7	2.7
Total	195.8	153.2	23.5

Incinerator C

Design and Operating Parameters

Type :	2 Chambered Controlled Air
Burners :	Primary
:	Secondary
Heat Recovery :	None
Emission Controls :	Wet Scrubber
Combustion Temperature :	1700-2000 °F primary
:	1900-2100 °F secondary
Waste feed rate :	550-805 lb/hr

INCINERATOR C
Schematic of Refuse Incinerator
and Sampling Location


~400°F
Exhaust Stack
Sampling Ports
Muffler
Reheat Burner
I.D. Fan
Demister
150°F-175°F
Venturi Scrubber
Sampling Ports
Cap
Dump Stack
Control Chamber
1900°F - 2100°F
Primary Chamber
1700°F - 2000°F

Incinerator C

Metals, HCL and PM Emissions

	inlet	outlet
Arsenic	-	0.01
Cadmium	-	0.50
Chromium (total)	-	0.07
Iron	-	5.90
Manganese	-	0.06
Nickel	-	ND
Lead	-	11.58
HCL	759 ppmv	1.86 ppmv
Particulates	0.05 gr/dscf	0.003 gr/dscf

Incinerator C

Dioxin and Furan Emissions

(2,3,7,8) substituted

Dioxins	Inlet ng/sec	Outlet ng/sec	Toxic Equivalence
TCDD	0.08	0.02	0.02
PeCDD	0.37	0.10	0.10
HxCDD	1.32	0.49	0.02
HpCDD	4.69	1.72	0.05
Total	6.46	2.33	0.19
Furans			
TCDF	0.82	0.21	0.21
PeCDF	3.51	1.37	1.37
HxCDF	7.53	3.86	0.12
HpCDF	14.47	5.11	0.15
Total	26.33	10.55	1.85

Incinerator D

Design and Operating Parameters

Type : 2 Chambered Controlled Air

Burners : Primary
: Secondary

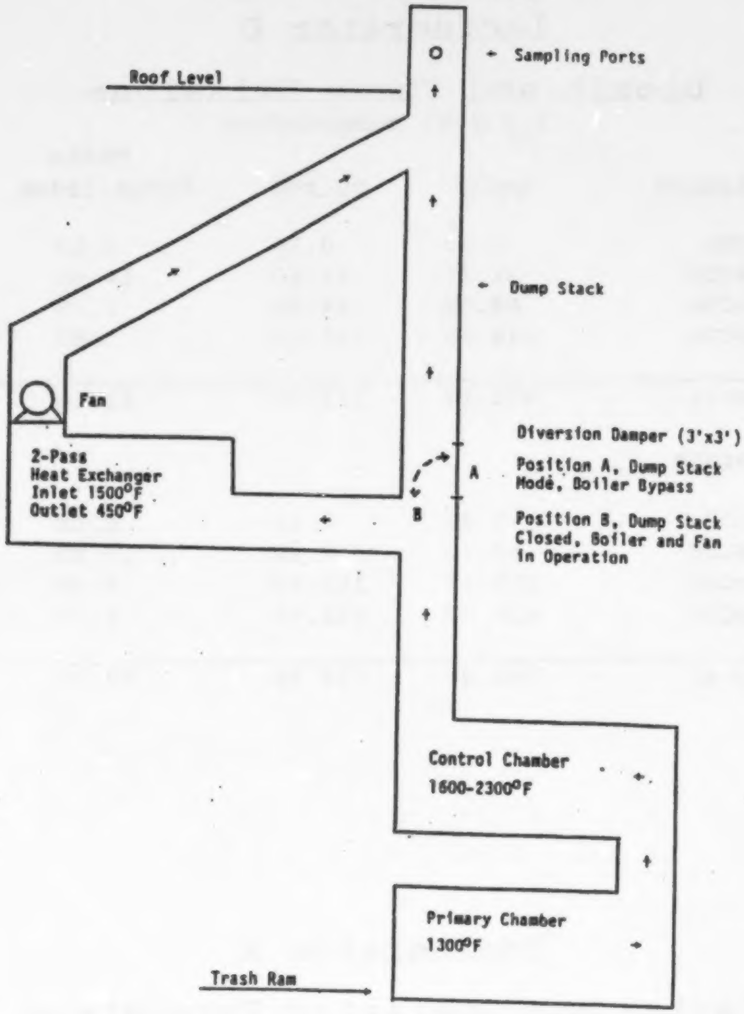
Heat Recovery : Boiler /Steam Generation

Emission Controls : none

Combustion Temperature : 1450 °F primary
: 1400-1600 °F secondary

Waste feed rate : 369-593 lb/hr

INCINERATOR D
Schematic of Hospital Refuse
Incinerator and Sampling Locations


Sampling Ports
Roof Level
Dump Stack
Fan
2-Pass
Heat Exchanger
Inlet 1500°F
Outlet 450°F
Diversion Damper (3'x3')
A
B
Position A, Dump Stack Mode, Boiler Bypass
Position B, Dump Stack Closed, Boiler and Fan in Operation
Control Chamber
1600-2300°F
Primary Chamber
1300°F
Trash Ram

Incinerator D

Metals, HCL and PM Emissions

	gm/hr	gm/ton
Arsenic	0.002	0.01
Cadmium	0.31	1.55
Chromium (total)	0.05	0.25
Iron	4.81	24.0
Manganese	0.12	0.6
Nickel	ND	ND
Lead	5.58	27.9
HCL	5.79 lb/hr	315 ppmv
Particulates	1.38 lb/hr	0.057 gr/dscf

Incinerator D

Dioxin and Furan Emissions

(2,3,7,8) substituted

Dioxins	ng/m^3	ng/sec	Toxic Equivalence
TCDD	0.20	0.14	0.14
PeCDD	21.17	14.60	14.60
HxCDD	64.56	44.10	1.32
HpCDD	246.23	169.00	5.07
Total	332.16	227.84	21.13
Furans			
TCDF	7.52	6.05	6.05
PeCDF	98.70	67.60	67.60
HxCDF	215.37	213.90	6.42
HpCDF	428.37	292.40	8.77
Total	750.0	579.95	88.84

Incinerator E

Design and Operating Parameters

Type : Single Chamber
Afterburner

Burners : Primary
: Secondary

Heat Recovery : none

Emission Controls : none

Combustion Temperature : 600-800 °F Primary

: 1400-1600 °F Afterburner

Waste feed rate : 70-100 lb/hr

Incinerator E

Metals, HCL and PM Emissions

	gm/hr	gm/ton
Arsenic	0.01	0.29
Cadmium	0.26	7.43
Chromium (total)	ND	ND
Iron	0.59	16.86
Manganese	0.03	0.86
Nickel	ND	ND
Lead	3.59	102.57
HCL	1.5 lb/hr	770 ppmv
Particulates	0.12 lb/hr	0.04 gr/dscf

Incinerator E

Dioxin and Furan Emissions

(2,3,7,8) substituted

Dioxins	ng/m^3	ng/sec	Toxic Equivalence
TCDD	0.02	0.004	0.004
PeCDD	0.22	0.038	0.38
HxCDD	1.17	0.196	0.006
HpCDD	9.39	1.575	0.047
Total	10.80	1.813	0.095
Furans			
TCDF	0.22	0.038	0.038
PeCDF	8.89	1.492	1.492
HxCDF	10.90	1.829	0.055
HpCDF	31.25	5.242	0.157
Total	51.26	10.550	1.742

Comparison of Selected Emissions From Incinerators

Incinerator	Control	Heat Recovery	Dioxins (ng/sec)	Cadmium (gm/hr)	Lead (gm/hr)
A	no	yes	43	0.7	9.9
B	yes	yes	27	1.5	12.9
C	yes	no	2	0.5	11.6
D	no	yes	110	0.3	5.6
E	no	no	2	0.3	3.6

HOSPITAL INCINERATOR TESTING IN NEW YORK STATE

Robert Waterfall
New York Department of
Environmental Conservation
Division of Air

Presented at:

**HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP**

Golden Gateway Holiday Inn
San Francisco, CA
May 10-12, 1988

THE PROGRAM

- Existing site survey
- Preliminary test
- Complete test series (tentative)

SURVEY QUESTIONS

- Charge rate?
- Hours of operation?
- Ram feed?
- Atmospheric damper?
- Heat recovery?
- Method 5 site?

SURVEY RESULTS

- 25 sites contacted in upstate New York
- 11 with heat recovery
- 4 with method 5 site

PRELIMINARY TEST

- Albany Medical Center
- Just completed in April 1988
- Contaminants:

Arsenic	Mercury
Cadmium	HCl
Chromium	CEMs
Lead	Organics

ALBANY MEDICAL CENTER INCINERATOR

- Ram feed
- 1280 lb/hr capacity
- 900 lb/hr average
- Ash removed daily
- 60% red bag/40% cardboard

ANTICIPATED UPGRADE

- Larger secondary
- Continuous Ash removal
- Venturi and packed scrubbers
- Stack gas reheat

PRELIMINARY TEST RESULTS

(All results are at 7% O_2)

Cadmium	4.25 mg/dscm
Chromium	<0.4 mg/dscm
Lead	3.57 mg/dscm
Mercury	8.45 mg/dscm
Chlorobenzene	0.04 mg/dscm
HCl	2000 ppm
SO_2	<100 ppm
NO_x	~150 ppm

PRELIMINARY RESULTS AT-A-GLANCE

- Particulate -- High
- Combustion gases -- Cyclic
- SO_2 and NO_x -- Low
- Organics -- Benzene, Chlorobenzene

OPERATING INSIGHTS

- High BTU loads
- Red bag contents
- Manually timed loading
- Water injection

COMBUSTION GASES

- NO_x ↑, CO ↑, O_2↓
  Poor burnout
  Load just charged
- NO_x ↓, CO ↓, O_2↑
  Clean operation
  Combustion stable

COMPLETE TEST SERIES

- Planned for NYC in summer 1988
- Funding questionable
- Varied operation
- Contaminants:
  - Dioxins
  - Metals
  - Particulate
  - Organics
  - HCl
  - CO_2
  - O_2
  - CO
  - SO_2
  - NO_x

BIOMEDICAL WASTE INCINERATOR PROGRAMS IN ONTARIO
(Biomedical Waste Workshops, San Francisco,
May 10-12, 1988, Baltimore 24-26, 1988)

Vlado Ozvacic
Air Resources Branch
Ontario Ministry of the Environment

Background:

There are over 130 biomedical waste incinerators (BWIs) located on hospital premises in Ontario. Some hospitals burn only general waste in their incinerators - pathological waste, which can be defined as the waste containing human or animal tissue or is infected with communicable disease or contains body fluids, is sent away for incineration. Waste generated in cancer-treating hospitals may contain more chlorinated plastics in comparison to other hospitals.

BWIs in Ontario are small and could be classified into batch types or semi-continuously fed two-chamber types. The semi- continuous incinerators are charged with waste periodically throughout the operational period via a ram-feeding mechanism. Most incinerators are operated four to ten hours a day, five days a week. Almost all incinerators contain either afterburners or secondary stage burners, complying with the Ministry's 1974 design criteria for the combustion gas residence time of 1/2 second at 1000°C. A typical batch incinerator may contain one or more chambers with a primary burner and an additional burner in a small compartment within the primary chamber for pathological waste. Some of the existing incinerators comply with the Ministry's 1986 design criteria of one second residence time at 1000°C for the combustion gas.

Operators of new BWIs in Ontario are required to continuously monitor opacity and total organic matter or carbon monoxide, to control the operation of the incinerator and to minimize the air emissions (1).

There are no measured air emission data for a number of toxic pollutants from any type of BWI in Ontario today. Some preliminary measurements of total hydrocarbons in the stacks of these incinerators indicated that unburned organic matter may be emitted into the air and that the emission quantities may depend on the operational cycle and incinerator design. A testing program to examine this dependance of emissions on the operating conditions and to develop air emission data base for BWIs has been in progress in Ontario since 1987.

The testing of Continuous Emission Monitors at BWIs

New BWIs in Ontario must be equipped with continuous emission monitors (CEM) for opacity and total hydrocarbons (THCs) or carbon monoxide (CO), to provide for optimum operation and to minimize the air emissions from these incinerators.

Several factors including high temperature, corrosive nature of the exhaust gases and the intermittent operation of BWIs could present difficulties in deciding on the level of sophistication of instrument package and its cost. In order to examine these factors and to specify appropriate policy guidelines, the Air Resources Branch conducted CEM experiments using commercial instruments at two BWIs in Toronto in 1987.

The two incinerators in the study, denoted as A and B, are both recently built two-chamber, ram-fed types.

Incinerator A is a Consumat C-325 model, controlled air two-chamber type, designed to burn 267 kg/h of biomedical waste. The primary chamber is operated with excess air. The secondary chamber is sized to provide 1/2 second residence time at 1000°C for the combustion gas. The incinerator stack emissions are visible occasionally when the waste containing high level of plastics is burned. The waste for incineration contains small anatomical parts, infectious laboratory waste including residuals of body fluid samples, swabs, disinfectants, alcohols, needles sharps, small containers and general waste.

Incinerator B is a Trecan Combustion's two-chamber controlled air model Trecaire 11, designed to burn 160 kg/h of BWI or 55 kg/h of pathological waste (Figure 1). The primary chamber is operated under starved air condition and the secondary chamber provides 1/2 second residence time at 1000°C for the combustion gas.

The choice of CEMs for the study was based on the simplicity of design and low cost in comparison to more sophisticated monitors.

The opacity meter was a double-pass type, even though less expensive single-pass opacity meters could be used at some BWIs. Double-pass instrument was necessary for this study because of (unexpected) opacity emissions during the incinerator dormant (noncombustion) periods and, hence, inability to zero single-pass monitors on daily basis. The instrument, a Sick RM 61 Transmissometer, utilizes a split-beam measurement technique with a folded path optical system. The projection windows were flushed with filtered air continuously to avoid dust deposition. The cost of the opacity instrument package including the meter, high temperature mountings, air blower and calibration filters was $8000 in 1987.

The initial calibration of the transmissometer and the zero-calibration reflector was performed on a weekend when the stack was clear. Subsequent daily calibration checks were carried out by inserting the zero-calibration reflector to simulate the clear stack condition, and the measurement span was checked with a neutral density filter.

Flame ionization technique was used to measure THCs - the analyzer was a heated Ratfish RS5. The extracted sample was transported through a probe and heat-traced both the primary filter and the sample line. The analyzer was calibrated with purified air and a mixture of propane in nitrogen. The calibration checks of the analyzer were frequently done by injecting the gases directly into the analyzer whereas daily injections into the probe ahead of the primary filter were used to determine the calibration drifts. The cost of the instrument package was estimated at about $16000 in 1987.

The monitor for carbon monoxide was an extractive type, measuring a preconditioned gas sample. The gas sample was aspirated from the stack with a steam eductor, and the mixture of the sample and steam was transported to a condenser to remove water prior to entering the analyzer. The analyser was a NOVA 7200 with electrochemical sensor. The calibration drifts for the whole measurement system were performed daily. The cost of the system including the steam ejector, sample lines, condenser and the analyser was $8000 in 1987.

Both extractive monitors, THC and CO, were recalibrated whenever daily drifts exceeded 2% of the gas calibration values.

Stack gas temperatures were measured with a K-thermocouple placed in a ceramic shield. The thermocouple calibrations checks were done in the field periodically by comparing its readings with another thermocouple.

Calibration Drifts:

The monitoring systems showed a reasonably low calibration drifts except for the THC system at the incinerator A (Table 1). The high 13% average drift of this system was due to frequent fouling of the instrument capillary tube, requiring weekly cleaning of the FID detector. There was no fouling at the incinerator B where the THC concentrations were lower than at the incinerator B.

CEM Results:

The main result of the CEM study was a successful demonstration that the continuous monitoring of opacity, THCs and CO in BWI stacks is feasible using commercially available instruments of reasonably low cost. THC monitoring systems may require frequent servicing at incinerators emitting higher quantites of THCs - the alternate CO monitoring systems require less maintenance.

The instrument readings reflected the incinerator operations. Examples of typical 24-hour traces of opacity, THCs and CO at the incinerator A are shown in Figures 2,3 and 4. In the case of opacity, the instrument-traced peaks were confirmed by visual observation of stack emissions. These peaks occurred approximately one minute after each ram push and lasted 1/2 minute on the average.

Opacity levels were significant when the incinerator was not operated. These dormant incinerator emissions peaked during the ash cleanout prior to the incinerator start-up (Figure 2). At 8 AM, the secondary burner was lit, the waste feeding started at 10 AM. Feeding stopped at 8 PM and the secondary burner was shut down at 10 PM. The peaks on Figure 2 during the incinerator operation corresponded to waste loading.

Similar behavior was noted for THCs and CO shown in Figures 3 and 4, respectively. Dormant emissions were also noted at the incinerator B, even though at a lower level than at the incinerator A.

It is suspected that the dormant emissions at both incinerators were a result of pyrolysis of unburned ash left in the furnace overnight, sustained by air drafts through open doors or other openings in the furnaces.

The average values of all three pollutants during the operational and nonoperational periods at the two incinerators are shown in Figures 5 and 6.

BWI Testing Program

The purpose of testing the BWIs in Ontario is to develop data base required for the specification of standards for air emissions and ash disposal; for the evaluation of design criteria for these incinerators; for the specification of air emission abatement equipment and for risk analyses. Hence, the BWI testing program was designed to measure air and ash emissions, the efficiency of air emission abatement equipment and the effect of combustion gas residence time and temperature in the secondary chambers or afterburners. The process and waste data have been collected during testing.

The testing program includes 10 BWIs; batch and semicontinuous; two-chamber incinerators with either starved air or excess air in primary chambers; different incinerator makes; different gas residence time in secondary chambers; different PVC content and the increased content of other plastics in the waste; the incinerators equipped with either dry scrubbers and baghouses or liquid scrubbers.

Five classes of air pollutants are measured at each incinerator, using separate sampling trains/systems for each class;

- Organics such as dioxins (PCDDs), furans (PCDFs), polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), chlorophenols (CPs) and chlorobenzenes (CBs). One out of the total of three samples collected at each incinerator is being tested for mutagenicity (Ames test).

- Volatile organics - initially, semiquantitative scans will be made in order to specify specie for analyses.

- Trace metals and radioactivity - similarly to tests for volatile organics, species for analyses will be determined after making semiquantitative scans.

- Gaseous pollutants by CEM, including HCl, NO_x, SO_x, CO, CO_2, O_2 and THCs.

- Microorganisms. The tests also involve challenging the incinerators with the known quantity of Bacillus Cereus spores.

The program was designed by various branches of the Ministry of the Environment. Ministry laboratories provide chemical analyses and other laboratory measurements; the Laboratory Services Branch coordinates the analytical work. An outside commercial laboratory is performing the analyses for volatile organics. Clayton Environmental Consultants carry out stack sampling, process observation and prepare the reports. The Air Resources Branch provides CEM and the overall program coordination.

The BWI testing program is divided into four phases. The testing of three incinerators has been completed, however, only some analytical results are available to date.

Results of the BWI Testing Program:

The CEM plots of opacity, CO and HCl taken at Humber Memorial Hospital (No.2) and Womens' College Hospital

(No.3) are shown in Figures 7 - 12. The incinerator No.2 is an old batch type made by Plibrico, while No.3 incinerator is the two-chamber type already discussed in the CEM program description as incinerator B.

The concentrations of all three pollutants were the highest at the start of the batch at the incinerator 2, and they gradually decreased towards the end of the batch. The concentrations were more evenly distributed throughout the testing period at the semi-continuously fed No. 3 incinerator. HCl concetrations were dependent on the feed rate at the same hospital and this dependance is illustrated in Figure 13.

The preliminary results of the tests completed at the first three hospitals are available for some species. They are shown in Table 2.

No microrganisms were found in air emissions at either of the three incinerators during or before the burn (backgroud sampling). No spores were found in the ash, only some bacterial growth in the ash sample extracts was reported. The only positive bacteria results were obtained in the samples of air around one of the tested incinerators.

No radioactivity (alpha, beta or gamma rays) was reported to be present above the method detection limit on either particulates or impinger extracts in the samples analysed to date.

Vlado Ozvacic

Reference: Continuous Emission Monitoring for Biomedical Waste Incinerators, Draft Policy Guideline, Ministry of the Environment, 1988.

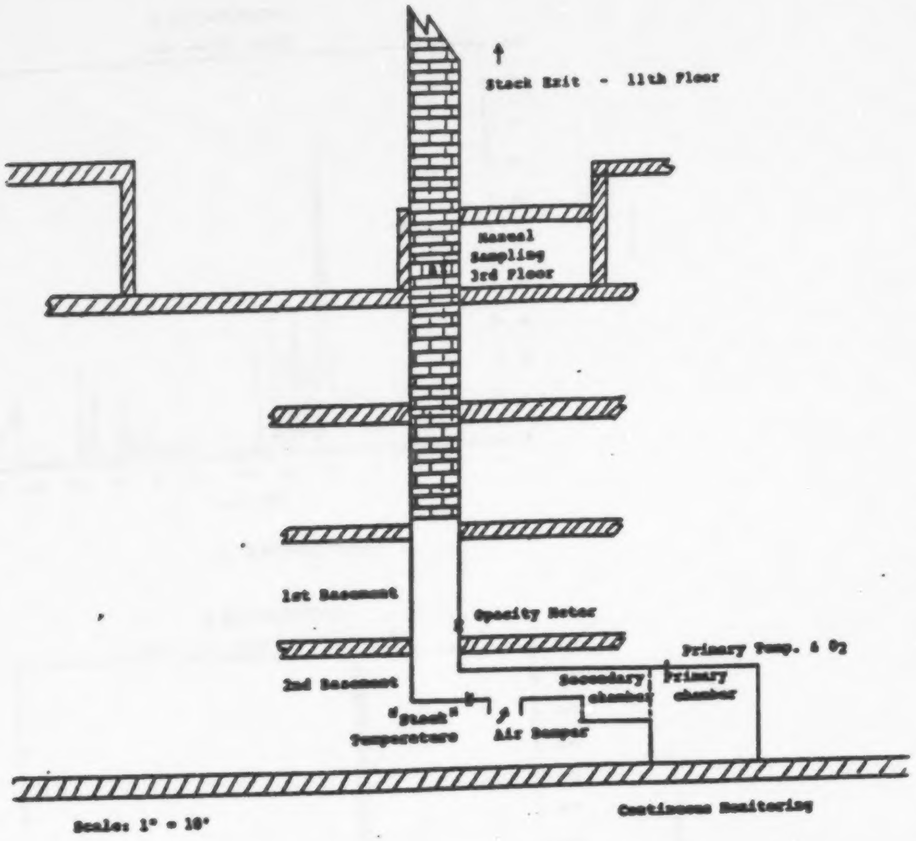

Stack Exit - 11th Floor
Manual Sampling 3rd Floor
1st Basement
Opacity Meter
Primary Temp. & O_2
2nd Basement
Secondary chamber
Primary chamber
"Stack" Temperature
Air Damper
Continuous Monitoring
Scale: 1" = 10'

Figure 1: Schematic Representation of Sampling Locations at Women's College Hospital

	Opacity	THC	CO
Incinerator A	0.4	-13	0.1
Incinerator B	1.1	0.4	-0.3

TABLE 1. AVERAGE CEM DRIFT (% full scale per day)

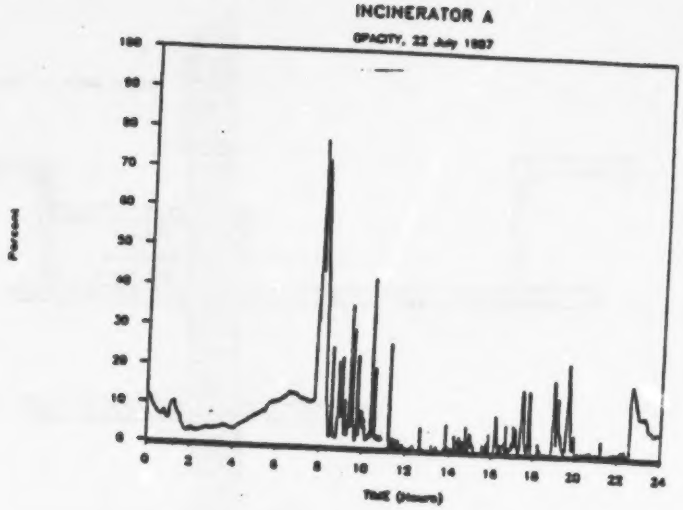


FIGURE 2.

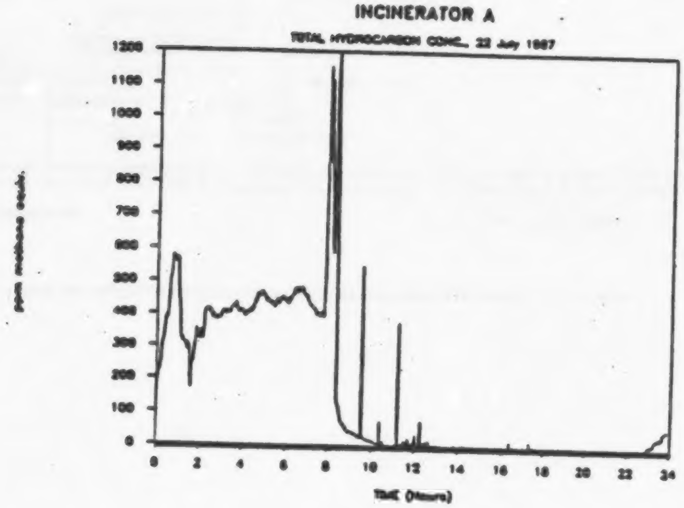


FIGURE 3.

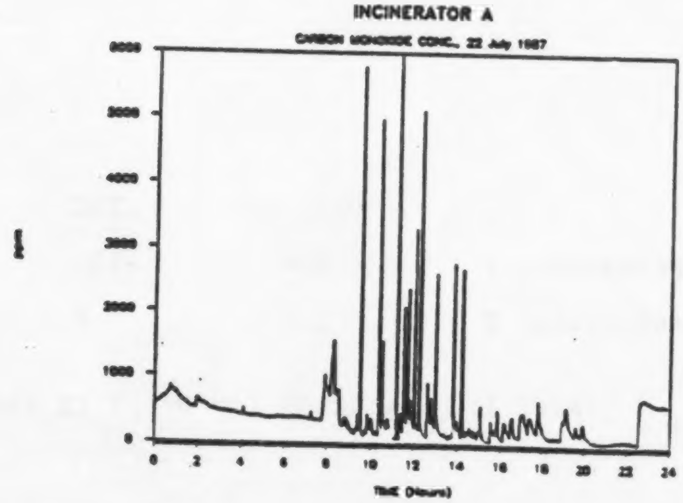


FIGURE 4.

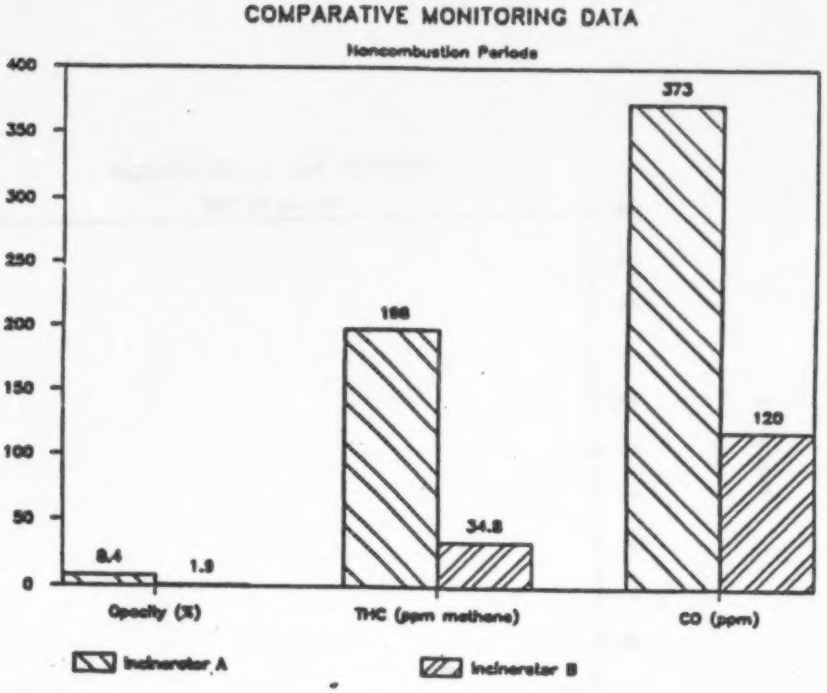


FIGURE 5.

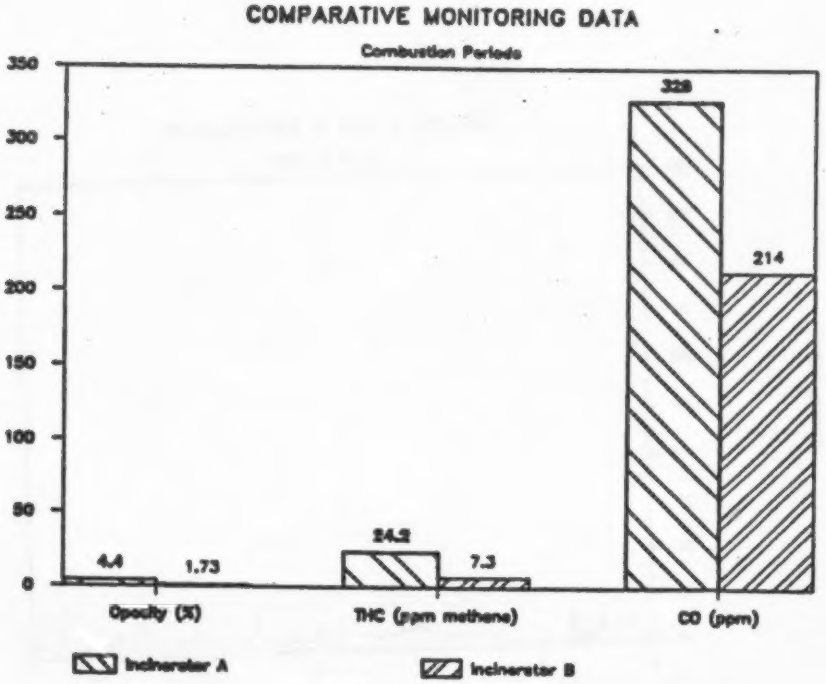


FIGURE 6.

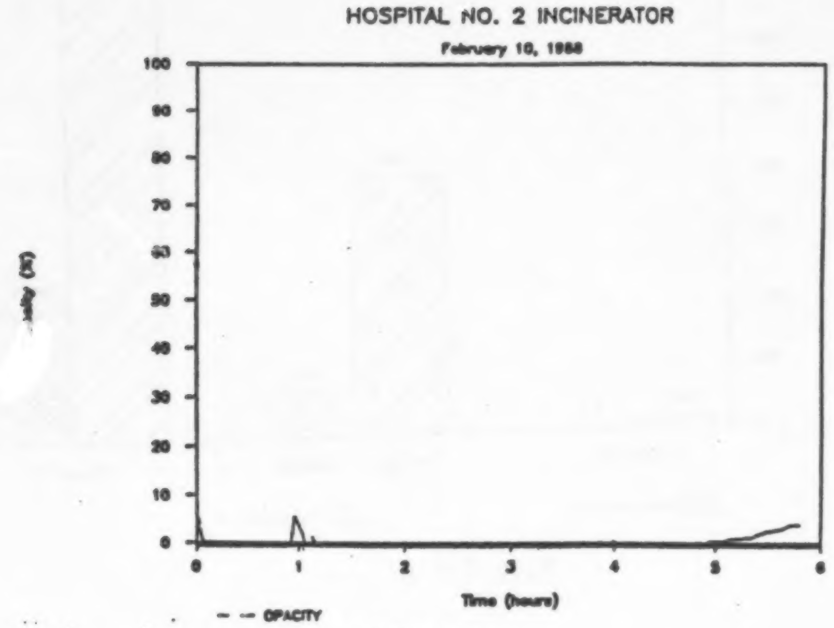


FIGURE 7.

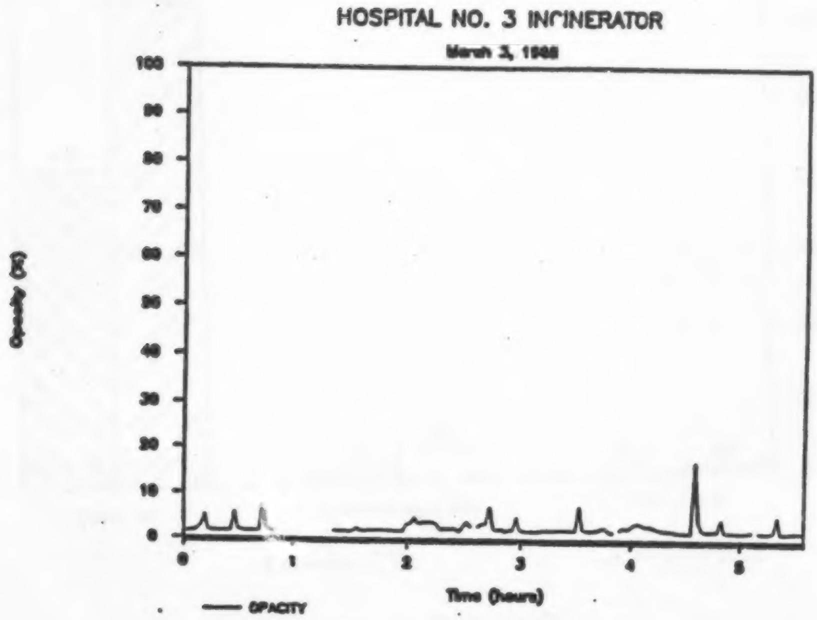


FIGURE 8.

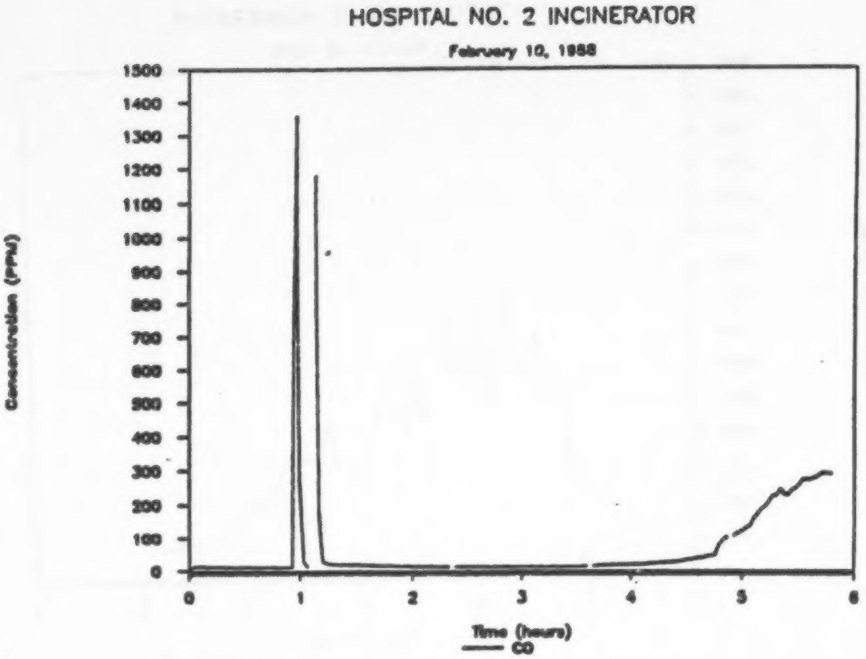


FIGURE 9

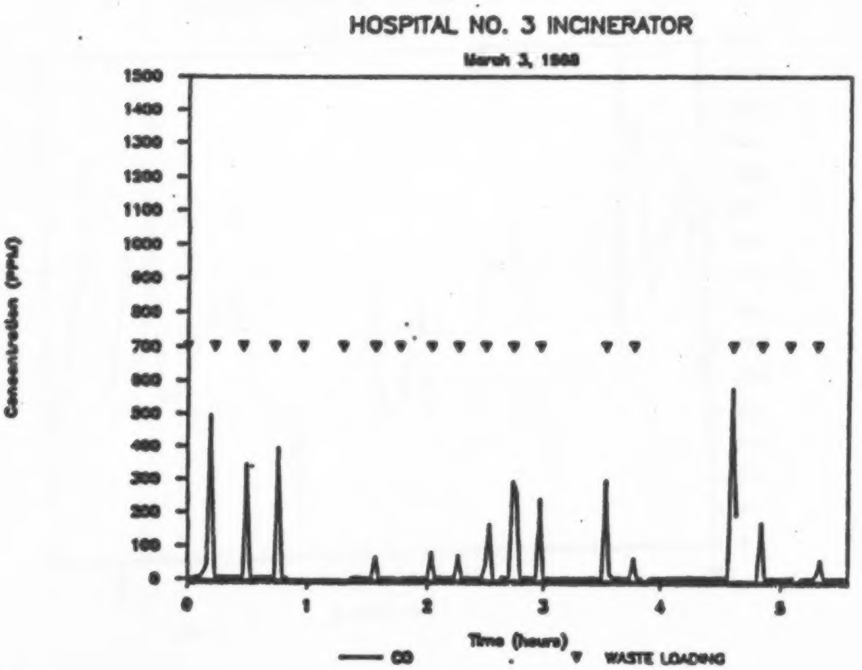


FIGURE 10

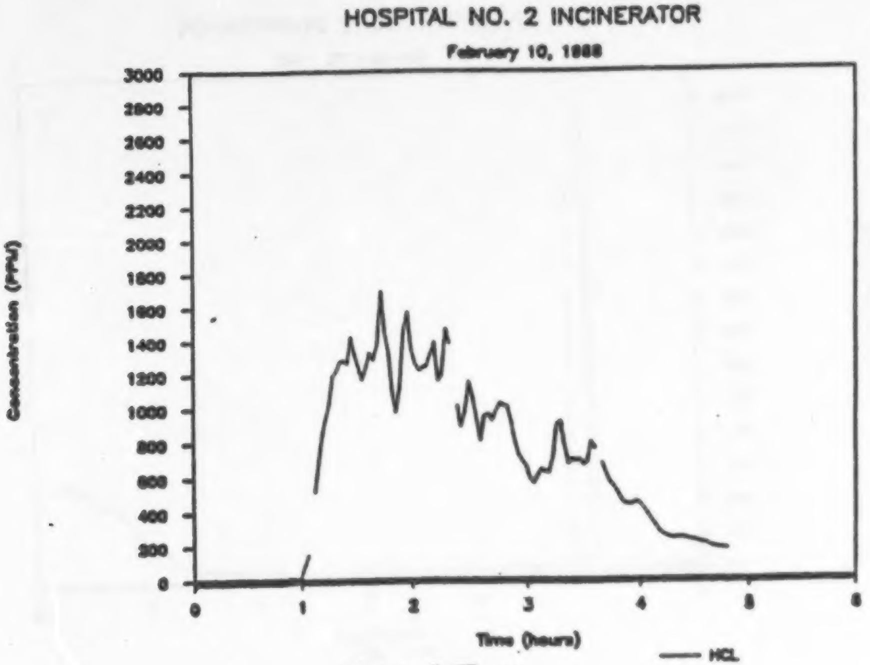


FIGURE 11.

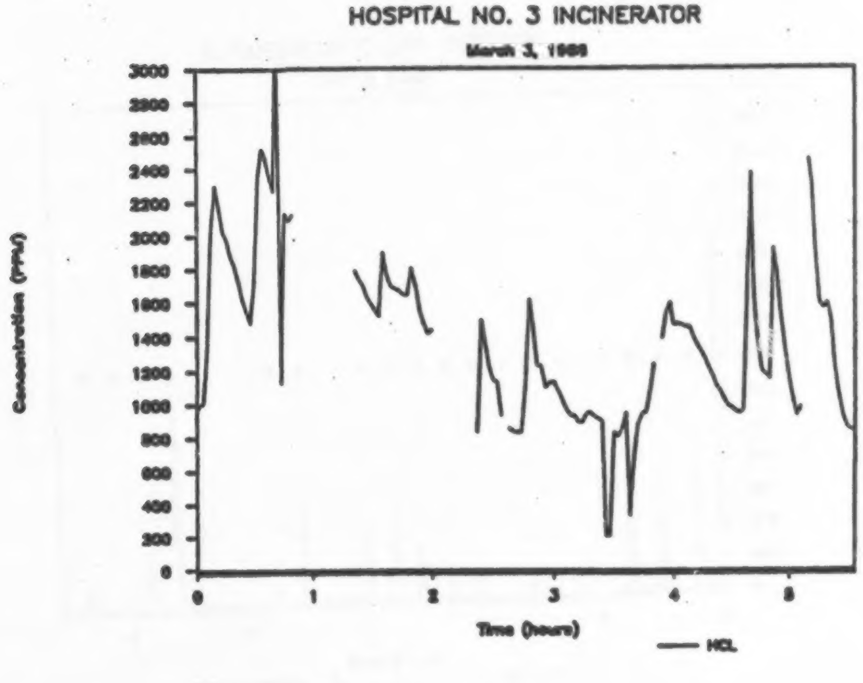


FIGURE 12.

HCL CONCENTRATIONS VS. WASTE MASS

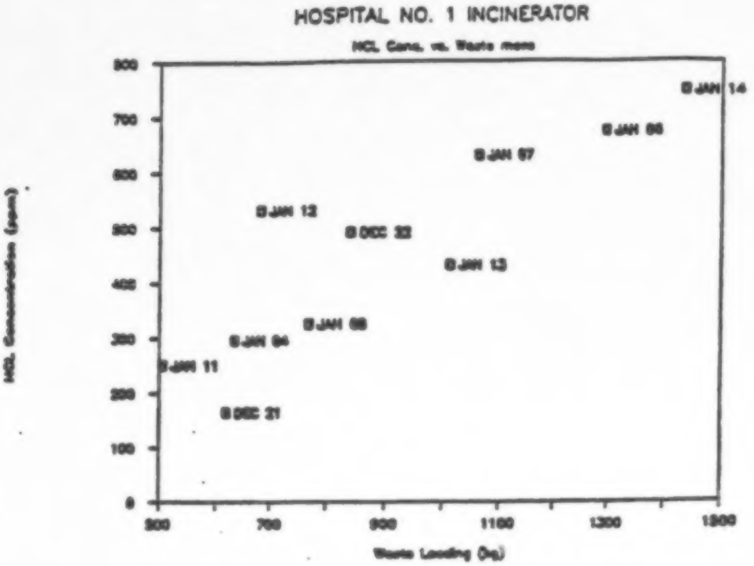


FIGURE 13.

Incin. No.	Total Particul. g/kg	PCDD/PCDF	PCBs	CBs	PAHs	HCl	THC	SO_2	NO	CO_2
		ng/DSCM					ppm			%
1	1	10- 30	ND	4-13	ND	487	3	25	68	7
2	1	32-260	NA	NA	NA	612	18	23	63	6
3	13	NA	NA	NA	NA	1250	14	30	100	8

NOTE: No microorganisms or radioactivity were detected

PCDD/PCDF - total dioxins and furans with 4 and more chlorines
CBs - chlorobenzenes
PAHs - polyaromatic hydrocarbons
g/kg - gram emitted per kilogram of waste
ng/DSCM - nanograms per dry standard cubic meter
ppm(%) - parts per million(percent) by volume

TABLE 2. Preliminary results of stack testing at BWIs

SESSION III: SOURCE DATA AND STACK TESTING

SUMMARY OF DISCUSSION (SAN FRANCISCO)

Q: Tests on municipal incinerators in New York found that heat recovery devices have significant effects upon dioxin formation. Please elaborate.

A: (R. Waterfall, NY DEC) Tests done in New York and elsewhere show that as the gases cool down more dioxin would be found. Three sites were tested: a large waterwall, a small modular, and an ESP. An increase of dioxin and furans content of the flue gas was found between the boiler and the control equipment.

Q: Didn't CARB data say the opposite, that after the scrubber less dioxin was found?

A: (G. Yee, CARB) No. Of the five boilers tested, CARB did not test across the heat recovery boilers. With a heat recovery boiler the temperature after the secondary chamber drops to a range where dioxin formation is possible. Incinerators without heat recovery, where stack temperatures are 1200°-1400°, should have lower dioxin levels after the secondary chamber. For facilities with control devices (bag houses and scrubbers), dioxin levels were lower after the controls, regardless of heat recovery.

Q: Please comment on pathogen testing.

A: (V. Ozvacic, ON Min. of Env.) Ontario used three sampling trains: one for stack emissions, another during the combustion period (a pre-burn sample), and an ambient air sample used for combustion. Bacteria counts came from the waste. Pre-burn samples and ambient air showed bacteria growth. The ambient air sample counts were due to samples being taken from the air where the waste bags were stored. No bacteria counts were taken from the combustion emissions.

(G. Yee, CARB) CARB conducted pathogen baseline testing of a filter sample, stack emissions, and a blank. The test indicated no pathogens or growth. However, there was some growth on the blank due to contamination. The results are currently being analyzed on a seventh test of infectious waste incineration for a heat recovery boiler with a magnesium hydroxide scrubber. The plan in the future is to spike a known quantity within a waste stream and measure the destruction efficiency through the incinerator.

Q: Where does the lead come from?

A: (V. Ozvacic, ON Min. of Env.) Perhaps the source is printed material in the general waste.

(G. Yee, CARB) Lead may come from radioactive types of medicines kept in lead containers.

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Q: It seems that heat recovery causes precipitation of dioxin within the flue. For those not using heat recovery the dioxin formation may be occurring in the atmosphere instead as the dispersing gases cool down. Are there data to support this theory?

A: (G. Yee, CARB) This is a good possibility if there is no heat recovery, but dispersion of gases would reduce any formation of dioxins in the plume. Measurements at stacks may not truly reflect the potential total emissions downstream in the ambient air.

(P.K. Leung, Env. Can.) A joint study by Environment Canada and EPA will be beginning in September. From this study, we may be able to determine where dioxin is formed in the process. EPA's Combustion Facility in Cincinnati, Ohio, is also conducting a theoretical study on the mechanics of dioxin formation in combustion sources.

(V. Ozvacic, ON Min. of Env.) Lab and plant studies at the University of Waterloo in Germany show that dioxin can be formed from the precursors at intermediate temperatures between 200° and 500° C when stack gases are not sufficiently cooled. At the Prince Edward Island facility's secondary chamber, on the inlet to the boiler, there were significant dioxin emissions coming out of the boiler. Silica on the fly ash may be promoting the growth or the coupling of various chemicals into dioxin formation. Also, pyrolysis was noted on the inlet to the boiler. This pyrolysis could have given rise to dioxin formation in the boiler. Maybe the temperature were too high. Again, scrubbers can remove dioxin formed in the heat recovery system. But then you have them in your lime, in your baghouse catch, or in the liquid.

SESSION III: SOURCE DATA AND STACK TESTING

SUMMARY OF DISCUSSION (BALTIMORE)

Q: There is evidence in the literature that bis-chloromethyl ether (BCME), a potent carcinogen, may be formed in poorly performing incinerators as a reaction product of aldehydes and HCl. Has BCME been sought in tests? Secondly, have chlorobenzenes been sought? They are associated with PVC in the waste and may be good dioxin surrogates. There is evidence that if chlorobenzenes are destroyed, dioxins will not be a problem.

A: (G. Yee, CARB) These compounds have not been sought. However, California data reported high benzene concentrations, possibly due to xylene. Xylene is used commonly in hospitals, and during combustion is transformed into benzenes. Using chlorobenzenes as an indicator, as has been proposed by EPA, can be misleading for overall assessment. Only good basic design and combustion can assure clean operation.

Q: Can an emission or concentration limit for CO be used as a surrogate for THC?

A: (V. Ozvacic, ON Min. of Env.) Ontario has a 100 ppm THC standard, but THC can be hard to measure. CO monitoring is favored because of its simplicity and reliability.

Q: What are the sources of Hg emissions?

A: (V. Ozvacic, ON Min. of Env.) It is difficult to determine. Perhaps batteries are a major contributor. Agencies may want to consider requiring hospitals to separate batteries from other waste.

Q: Some agencies are advocating higher retention times in the secondary chamber. Do the data justify doubling the time (from 1 to 2 seconds) or are these "seat of the pants" judgments?

A: (V. Ozvacic, ON Min. of Env.) Two seconds at 1000° C are needed to destroy dioxins, which are the main concern. Thermodynamically, dioxin should not exist above 500-600° C., but silica formed in fly ash may catalyze dioxin formation. Municipal incinerator data indicate that 1 second is not long enough.

(G. Yee, CARB) These parameters should not be defined as standards, but only as "Time-Temperature-Turbulence" design criteria.

(P.K. Leung, Env. Can.) The University of Dayton is conducting a study along these lines to improve understanding of combustion. For information contact EPA in Cincinnati.

Q: Even if organics are destroyed by suitable time-temperature conditions, they may recombine as the gases cool (especially in a heat-recovery boiler) and form dioxins. To eliminate this possibility, New York will require a residence time standard plus a very low HCl limit.

SESSION IV

TOPICS OF SPECIAL CONCERN: PATHOGEN SURVIVAL, RISK ASSESSMENTS, AND REGIONAL FACILITIES

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POTENTIAL RISK POSED BY HOSPITAL INCINERATORS IN NEW JERSEY

by

Joann L. Held
New Jersey Department of Environmental Protection
Trenton, New Jersey

presented at

Hospital Infectious Waste Incineration and Hospital Sterilization
Workshops
San Francisco - May 10, 1988
Baltimore - May 24, 1988

Summary

One objective of the New Jersey air toxics program is to identify source categories which pose potentially unacceptable risk and then develop state-of-the art guidelines for these sources. If necessary, regulations will be written to address existing sources. One source category that has already received some attention is hospital incinerators - both new and existing. A simple risk evaluation of three existing incinerators has been done using emission factors developed for incinerators in California and Canada. The preliminary results indicate that dioxin and hydrogen chloride emissions from these incinerators may be of concern, although they do not pose an immediate hazard.

NEW JERSEY INCINERATORS

Four hospitals in the northeast portion of the state were identified for a preliminary assessment of the risk posed by hospital incinerators. These incinerators were:

	Location	Feed Rate
St. Michaels Medical Center	Newark	430 lb/hr
Montclair Community Hospital	Montclair	30 lb/hr
Irvington General Hospital	Irvington	25 lb/hr
Beth Israel Hospital	Passaic	1 lb/hr

None of these incinerators is equipped with controls. Combustion chamber temperatures ranging from 1500 to 2300 F.

EMISSION FACTORS

Since no stack test information is available for the New Jersey incinerators, stack tests for similar facilities were sought. Two sets of data were identified.

1. F.C. Powell, 1987, "Air Pollutant Emissions from the Incineration of Hospital Wastes: The Alberta Experience." *JAPCA, 37*, PP. 836-839.

This report describes test results from 14 hospital incinerators in the Province of Alberta. Ten of these units were uncontrolled. The feed rate ranged from 85 to 2500 lb/hr. Hydrogen chloride (HCl) and particulate emissions are reported.

2. USEPA, 1987, "Hospital Waste Combustion Study: Data Gathering Phase." Final draft report, EPA Contract No. 68-02-4330.

Section 3.2 of this report contains test data from four large hospital incinerators (two in California, one in British Columbia, and one in Illinois). It also contains a summary of the Powell paper described above. The feed rate for these large incinerators ranged from 600 to 2200 lb/hr. Three units are uncontrolled, although both controlled and uncontrolled emissions are reported for the fourth unit. The following emissions are reported:

HCl, SO_2, NO_x, CO, Total Particulate
As, Cd, Cr, Fe, Mn, Ni, Pb
Total HC, Low molecular weight organics (8 species)
Tetra, Penta, Hexa, Hepta, Octa and Total PCDD
Tetra, Penta, Hexa, Hepta, Octa and Total PCDF

Emission factors for this exercise were chosen on the basis of unit size (represented by feed rate) whenever possible. The Beth Israel Hospital Incinerator was dropped from the analysis because none of the stack test reports were for such small units. The HCl and particulate emission factors from twelve Alberta incinerators were used because these particular incinerators were in about the same size range as the New Jersey incinerators, with feed rates of 85 to 740 lb/hr (compared to the three larger New Jersey incinerators which have feed rates of 25 to 430 lb/hr). For the remaining pollutants the factors reported by EPA for the two California units and the unit in British Columbia were used since no other data were readily available. The information on the Illinois incinerator was inadequate for use in this study.

Hydrogen Chloride and Particulate Emission Factors

The emission factors used for this evaluation are reported below.

Contaminant	(lb/Ton)	Source
HCl	14.6 - 99.4	12 Alberta Units
Particulate	1.69 - 36.49	12 Alberta Units

A range of factors was used because there was no clear trend between specific particulate and HCl emission rates and unit size. In fact, the highest particulate emissions were associated with the smallest units.

Metal Emission Factors

The following emission factors were used.

Contaminant	(lb/Ton)	Source
Arsenic	3E-4	2 Calif. + 1 B.C. Units
Cadmium	68E-4	2 Calif. + 1 B.C. Units
Chromium	20E-4	2 Calif. + 1 B.C. Units
Iron	183E-4	2 Calif. + 1 B.C. Units
Lead	580E-4	2 Calif. + 1 B.C. Units
Manganese	11E-4	2 Calif. + 1 B.C. Units
Nickel	5E-4	2 Calif. + 1 B.C. Units

These factors are the highest reported for the two California units and the unit in British Columbia. The highest value was chosen because the highest particulate emissions were associated with the smallest units and the New Jersey units are generally much smaller than these three units. It is very likely that the emissions for the New Jersey units are higher than estimated here.

Dioxin and Furan Emission Factors

As a first estimate of the risk posed by these incinerators, only the emissions of the Tetra homologue group of dioxins was used. The highest emission factor for TCDD was 2.07E-6 lb/Ton. In a follow-up study, other homologues and the furans may be evaluated.

Volatile Organic Compound (VOC) Emission Factors

Total hydrocarbons were measured but only eight low molecular weight organics were speciated in the California stack tests. The eight organics were ethane, ethylene, propane, propylene, trichlorotrifluoroethane, tetrachloromethane, trichloroethylene and perchloroethylene. Risk factors were only available for the last two substances, so they were the only VOCs included in the analysis. The emission factors were:

Contaminant	(lb/Ton)	Source
Perchloroethylene	2.5E-4	2 California Units
Trichloroethylene	2.4E-5	2 California Units

Criteria Pollutant Emission Factors

Emission factors were also available for sulfur dioxide, nitrogen oxides, and carbon monoxide. All of the emissions were low, in fact the carbon monoxide emissions were below the detection limit (50 ppmv for these tests). However, these emissions were still evaluated because they may serve as a useful frame of reference when comparing hospital incinerators to other types of combustion sources. The emission factors used were:

Contaminant	(lb/Ton)	Source
SO_2	3.01	2 California Units
NO_x	7.82	2 California Units
CO	<1.7	2 California Units

THE CALCULATIONS

Estimating Emission Rates

Emission rates for the 15 substances considered in this evaluation were calculated for each of the three New Jersey incinerators using the following formula:

$$\text{Emission Rate (lb/hr)} = \text{Feed Rate (lb/hr)} \times \text{Emission Factor (lb/ton)} \div 2000$$

Dispersion Modeling

The Industrial Source Complex (ISC) model was used to predict maximum 1-hour, 24-hour and annual average ground level concentrations. Newark meteorological data were used along with urban dispersion coefficients. No downwash analysis was performed since plot plans were not available for these hospitals. Because the stacks involved are relatively short, downwash is likely to cause higher ground level concentrations than predicted by the model.

The potential ambient impacts are summarized below. Annual average concentrations are reported for carcinogens and for criteria pollutants with annual or quarterly standards. Maximum 24-hour concentrations are reported for substances which have non-carcinogenic health effects associated with chronic or sub-chronic exposure. Maximum 1-hour concentrations are reported for substances with known adverse health effects associated with acute exposure to ambient concentrations.

LONG-TERM EXPOSURE TO CARCINOGENS

Annual Average Concentration (ug/m^3)

Contaminant	Montclair	Irvington	St. Michaels
Arsenic	9.0E-6	4.1E-6	2.7E-6
Cadmium	2.0E-4	9.4E-5	6.5E-5
Chromium	6.0E-5	2.8E-5	1.8E-5
Nickel	1.5E-5	6.8E-6	4.7E-6
Perchloroethylene	7.4E-6	3.4E-6	2.3E-6
Trichloroethylene	7.2E-7	3.3E-7	2.2E-7
TCDD	6.2E-8	2.9E-8	1.9E-8

CHRONIC EXPOSURE TO NON-CARCINOGENS

Maximum 24-Hr Concentration (ug/m^3)

Contaminant	Montclair	Irvington	St. Michaels
Iron	0.006	0.002	0.002
Manganese	0.0004	0.0001	0.0001
Perchloroethylene	8.2E-5	3.0E-5	2.2E-5
Trichloroethylene	7.9E-6	2.8E-6	2.0E-6

EXPOSURE TO CRITERIA POLLUTANTS

Annual Average Concentration (ug/m^3)

Contaminant	Montclair	Irvington	St. Michaels
Particulate	0.06-1.1	0.02-0.51	0.02-0.34
Sulfur Dioxide	0.10	0.04	0.03
Nitrogen Oxides	0.24	0.11	0.07
Lead	1.7E-3	8.0E-4	5.2E-4

Maximum 24-Hr Concentration (ug/m^3)

Contaminant	Montclair	Irvington	St. Michaels
Particulate	0.67-12.2	0.19-4.4	0.14-3.1
Sulfur Dioxide	1.1	0.38	0.26
Lead	0.019	0.007	0.005

ACUTE EXPOSURE ESTIMATES

Maximum 1-Hr Concentration (ug/m^3)

Contaminant	Montclair	Irvington	St. Michaels
HCl	13.2-89.7	3.1-21.1	2.8-19.3
Nitrogen Oxides	7.2	1.7	1.5
Carbon Monoxide	< 1.8	< 0.3	<0.3

RISK EVALUATION

The exposure estimates described above were compared to available standards, guidelines and other reference numbers. These are described below.

Carcinogens

Using unit risk factors derived by the USEPA Carcinogen Assessment Group from the 95% upper-bound of the risk model, the following range of risk was calculated. The unit risks represent the incremental risk associated with a life-time exposure to 1 ug/m3 of the contaminant.

Contaminant	Unit Risk	Range of Calculated Risk
Arsenic	4.3E-3	1.2E-8 to 3.9E-8
Cadmium	3.5E-3	2.3E-7 to 7.0E-7
Chromium	1.2E-2	2.2E-7 to 7.2E-7
Nickel	4.8E-4	2.3E-9 to 7.2E-9

Contaminant	Unit Risk	Range of Calculated Risk
Perchloroethylene	4.1E-6	9.E-13 to 3.E-12
Trichloroethylene	1.4E-5	3.E-11 to 1.E-10
TCDD	3.3E+1	6.3E-7 to 2.0E-6

Of these seven carcinogens, only TCDD exceeds one in a million risk. However, the particulate emission factors may be low and if future tests show that the cadmium and chromium emissions are higher than estimated, then the incremental risk for these two metals may also exceed one in a million.

Hydrogen Chloride

The maximum predicted ambient one-hour concentration of HCl is 90 ug/m3. This is very close to the odor threshold for HCl which has been reported to be as low as 98 ug/m3. Stinging and burning sensation in the eyes has been reported at about 4200 ug/m3. The maximum short-term concentration for the three New Jersey incinerators is only about 2% of this effect level. These two reference values seem to indicate that emissions of HCl from hospital incinerators require further investigation.

Criteria Pollutants

The maximum estimated concentrations of the criteria pollutants are generally less than or equal to 1% of the associated National Ambient Air Quality Standards (NAAQS), with the exception of the 24-hr concentration of particulate. The maximum estimated 24-hour concentration of 12.2 ug/m3 is about 5% of the old NAAQS for Total Suspended Particulate (260 ug/m3). If it is assumed that all of the particulate matter is inhalable, then the particulate concentration rises to 8% of the PM-10 standard (150 ug/m3).

Non-criteria Pollutants

Reference doses for chronic exposure to iron, manganese, perchloroethylene and trichloroethylene are not readily available. However, the predicted concentrations are so low - less than 0.01 ug/m3 - that it is unlikely that there are adverse health consequences associated with these emissions.

PATHOGEN SURVIVAL AT HOSPITAL/INFECTIOUS WASTE INCINERATORS

Presented at:

Hospital/Infectious Waste Incineration and
Hospital Sterilization Workshops
San Francisco - Baltimore
May, 1988

Prepared by:

Steven Klafka, Environmental Engineer
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Wisconsin Department of Natural Resources

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INTRODUCTION

In Wisconsin, air pollution control permits are issued for infectious waste incinerators by the Department of Natural Resources (WDNR), Bureau of Air Management. Since February of 1988 new solid waste rules have eliminated the need for a solid waste license to be issued to incinerator operators. As a result, the review of the air permit applications have addressed what might typically be considered a solid waste management issue - the release of infectious pathogens during incinerator operations.

SOURCES OF PATHOGENS

The release of infectious organisms from biomedical solid waste incinerator operations could potentially occur at three locations:

1. During waste transport and handling operations,
2. From the incinerator stack, or
3. From the residual ash.

DEFINITION OF INFECTIOUS WASTE

The factors needed to transmit an infectious disease include the following[1]:

Presence in the waste
Virulence or strength
Portal of entry
Dose
Resistance of host

With consideration given to these factors, a preliminary list of medical wastes to be treated as infectious during facility permitting has been developed by the Wisconsin DNR[2]. This is based in large degree on recommendations by the Center for Disease Control and the U.S. EPA.[1,6]

Infectious wastes are defined under s. NR 500.03(67), Wis. Adm. Code, to be:"A solid waste which contains pathogens with sufficient virulence and quantity so that exposure to the waste by a susceptible host could result in an infectious disease".

Typical hospital and health care facility wastes which may be considered infectious are:

1. Microbiological laboratory wastes including cultures and equipment which has come in contact with cultures of infectious agents;

2. Blood, blood products and bodily fluids including those from dialysis units;

3. Sharps including needles and laboratory glass wastes;

4. Surgical, autopsy and obstetrical wastes which have had contact with patient blood or body fluids;

5. Wastes which have had contact with patients in communicable disease isolation; and

6. Human and animal tissue containing pathogens with sufficient virulence and quantity so that exposure to the waste by a susceptible human host could result in an infectious disease.

Hospitals, clinics and nursing homes handle wastes in-house on the assumption that disease can be transmitted to staff and other patients.[6,7,8] It would be inconsistent not to extend similar precautions to protect solid waste handlers and the community at large. Once this premise is accepted it becomes a question of to what degree can solid waste be segregated to reduce or eliminate infectious waste. The problem is complicated, since some categories of infectious waste, such as needles, bandages, even I.V. and bodily fluid collection apparatus are found in municipal solid waste as a result of their use in home care practices. Large portions of infectious hospital wastes, such as patient isolation wastes, are identical in appearance to noninfectious general wastes. Obviously, separation of much of the potentially infectious waste requires cooperation with medical care establishments to establish standards as opposed to a typical industry/regulatory enforcement approach.

There appear to be few people in regulatory environmental agencies or consulting firms with backgrounds in microbiology or related para-medical areas. This results in a lack of perspective on the infection process or how diseases are transmitted. One example is that it can be accurately stated that infectious wastes contain fewer microorganisms than municipal wastes.[8] While true, this statement ignores the fact that we live in a sea of microorganisms that are present in our soil, food, and the external and interior potions of our bodies.[6] The potential to cause disease is a qualitative property of microorganisms more than a quantitative property.

Some of the waste categories designated as infectious would be more properly called "potentially infectious." For example, preserved pathological tissue is designated for incineration from an aesthetic sense than infectious disease concerns. Overall it should be recognized that the designation of infectious and noninfectious waste is a relative term. Establishing the six categories as infectious waste, controls what we believe are the most likely wastes to contain quantities of infectious organisms. However, it cannot be stated that other hospital wastes or municipal wastes will not contain infectious organisms.

RELEASE OF PATHOGENS DURING WASTE TRANSPORT AND STORAGE

Transmission of disease from infectious waste could potentially occur through needle sticks, spills, inhalation of aerosols and dust and ingestion of infectious agents.[3,7,8] The incidence of hepatitis B among medical care workers may be an indicator that this disease could be spread by careless handling of infectious waste. However, there is no epidemiologic evidence that infectious waste disposal practices have caused disease in the community.[4,6,7]

Prudent disposal practices include the use of containers which avoid injuries from sharps or spills of bodily fluids, and keeping all infectious wastes enclosed before treatment. The use of hard containers for sharps and the bagging and boxing of wastes has become a common practice for wastes transported to off-site infectious waste incinerators. The additional use of refrigeration for waste transport or storage is an unresolved issue, since the need for refrigeration is a variable related to the amount of materials that can biodegrade within the infectious waste component.

RELEASE OF PATHOGENS FROM INCINERATOR STACKS

Most stack tests on infectious waste incinerators confirm that under good operating conditions waste pathogens are not released from the stack.[10,11,12,13] However, stack testing for destruction of biological indicators in pathological incinerators has been limited or unpublished. The series of incinerator stack tests dating from the 1960s through the 1970s by Manuel S. Barbeito, et al, used highly temperature resistant bacterial spore forms to establish the effectiveness of incineration in destroying biological organisms. These nonpathogenic bacteria (Bacillus sp.) spore forms have traditionally been used to test the effectiveness of steam and gas sterilizers since they represent the most temperature (and perhaps chemical) resistant life forms among microorganisms. The most cited research is from the Barbeito and Shapiro paper from 1977 where they concluded that a minimum exposure to 1,400°F in the primary and 1,600°F in the secondary was necessary to assure destruction of the test spores. The incinerator tested provided a total of 1.2 seconds of exposure, but this recommendation didn't address residence times, only temperature, and was followed by a recommendation to stack test each new incinerator with spores.[11]

Wisconsin DNR infectious waste incineration guidelines have concluded that control of the physical design parameters at 1,800°F with a minimum secondary temperature of 2 seconds provides ample safety to assure total destruction of biologicals. However, this Department is following with interest, current spore stack testing of biomedical waste incinerators by the Ontario Ministry of Environment and proposed testing in California by the California Air Resources Board (CARB). We feel these tests are useful to further confirm the safety of design parameters of infectious waste incinerators, but we do not feel routine stack testing with spores is a necessary precaution. It should also be remembered that spore testing, while traditional and useful, is conservative representing a much more highly temperature resistant life form than the vast majority of infectious agents that are nonspore formers. Viral agents like hepatitis B and the AIDS virus HIV are fragile organisms difficult to even maintain in the laboratory and are easily destroyed by the adverse temperatures encountered in an incinerator.

RELEASE OF PATHOGENS FROM INCINERATOR ASH

During poor operating conditions, pathogens in municipal waste have been shown to survive the incineration process. Good burnout of infectious waste is needed to encourage complete destruction of waste pathogens.[14] In this case, the use of ash quality requirements for incinerators may be appropriate. Such requirements may include that there be no visible combustibles in the ash or a maximum fixed carbon content not be exceeded (i.e., 5 percent, by weight)[2]. This requires that close attention be given to not overcharging the incinerator.

[1] U.S. EPA, EPA Guide for Infectious Waste Management, p.2-1, May, 1986.

[2] Wisconsin Department of Natural Resources, Bureau of Air Management, Draft Guidelines for Infectious Waste Incinerators, April 22, 1988.

[3] Gordon, J., Forum: Infectious Waste - A Growing Problem for Infection Control, ASEPSIS - The Infection Control Forum, Vol. 9, No. 4.

[4] Rutala, W., Forum: Infectious Waste - A Growing Problem for Infection Control, ASEPSIS - The Infection Control Forum, Vol. 9, No. 4.

[5] Rutala, W., Sarubbi, F.,: Management of Infectious Waste from Hospitals, Infection Control, p. 198-204, 1983, Vol. 4, No. 4.

[6] CDC, Guidelines for Handwashing and Hospital Environmental Control, 1985.

[7] CDC, Recommendations for Prevention of HIV Transmission in Health Care Settings. MMWR Supplement, August 21, 1987, Vol. 36, No. 2S.

[8] Department of Labor/Department of Health and Human Services, Joint Advisory Notice on Protection Against Occupational Exposure to Hepatitis B Virus (HBV) and Human Immune Deficiency Virus (HIV). October 19, 1987.

[9] Kalnowski, G., Wiegand, H., Ruden, Henning: On the Microbial Contamination of Hospital Waste. Zentralblatt fuer Bacteriologic, Microbiologic, und Hygine (West Germany) 1983, pages 364-379.

[10] Kelly, N., Allen, R., Brenniman, G., Kusek, J.,: An Evaluation of Bacterial Emissions from a Hospital Incinerator, Proceedings VIth World Congress on Air Quality, 16-20 May 1983, Paris, France, Vol.2, May 1983, pages 227-232.

[11] Barbeito, M., Gremillion, G., Microbiological Safety Evaluation of an Industrial Refuse Incinerator, Applied Microbiology, p. 291-295, Feb., 1968.

[12] Barbeito, M., Shapiro, M., Microbiological Safety Evaluation of a Solid and Liquid Pathological Incinerator, Journal of Medical Primatology, 6:264-273, 1977.

[13] Barbeito, M., Taylor, L., Seiders, R., Microbiological Evaluation of a Large-Volume Air Incinerator, p. 490-495, Applied Microbiology, March 1968, Vol. 16, No. 3.

[14] Peterson M., Stutzenberger F.,: Microbiological Evaluation of Incinerator Operations. Applied Microbiology, July 1969, Vol. 18, No. 1, pages 813.

7447M

CORRESPONDENCE/MEMORANDUM STATE OF WISCONSIN

DATE: April 22, 1988 FILE REF: 4530

TO: Donald Theiler - AM/3

FROM: Michael Tierney - AM/3 MJ Tierney
Steven Klafka - AM/3 SKlafka

SUBJECT: Design and Operating Guidelines for Infectious Waste Incinerators

At the January meeting of the Natural Resources Board there was considerable discussion on the issue of solid waste incineration, including the burning of infectious hospital wastes. Afterwards, we were instructed to develop design and operation guidelines for new hospital waste incinerators. These guidelines would address the handling of infectious waste, emissions control and operator training. Subsequently, the proposed rules controlling hazardous air pollutants (Chapter NR 445, Wis. Adm. Code) were amended to require both new and existing infectious waste incinerators to control emissions of Table 3 known and suspected human carcinogens to the level which is lowest achievable emission rate, or LAER.

Attached are guidelines for the design and operation of infectious waste incinerators. These guidelines define LAER for Table 3 pollutants associated with the incineration of infectious wastes from hospitals and other health care facilities such as nursing homes and medical clinics. These guidelines also define infectious wastes, address proper waste and ash handling procedures, specify incinerator monitoring and testing requirements, and recommend operator training requirements.

Within the guidelines, lowest achievable emission rates for the Table 3 pollutants is expected if the recommendations are followed under B. Incinerator Design and Operation and F. Air Pollution Control Requirements. The organic compounds listed in Table 3 are reduced the greatest by good waste combustion. Minimum operating temperature and combustion gas residence time are specified. Solid phase pollutants and residual organic compounds listed in Table 3 are further controlled by particulate (TSP) control equipment and flue gas scrubbing equipment for hydrogen chloride (HCl).

The design and emission control requirements for large incinerators (i.e., 1,000 pounds per hour capacity or greater) are similar to those expected of new municipal waste incinerators. Under the proposed rules, municipal incinerators are also required to achieve LAER. The emission control technologies likely to achieve emission limitations specified for TSP and HCl are fabric filter baghouses in combination with dry or wet scrubbing, or steam injection wet scrubbers and potentially, high pressure drop venturi scrubbers. Medium sized incinerators (i.e., 200 to 1,000 pounds per hour capacity) would likely use venturi/packed bed wet scrubbers. Small incinerators do not require control equipment since it has yet to be proven feasible.

The design and associated emissions of infectious waste incineration facilities has only recently come under close scrutiny. Few facilities have emissions control equipment or have had extensive testing for hazardous air pollutants. This is especially true for small, batch feed systems under 200 pounds per hour in capacity. These LAER guidelines are based upon the information on existing incinerators we were able to obtain from other states, U.S. EPA, Canada, incinerator vendors and designers. As further information comes available, these guidelines will need to be updated. In the meantime, we obtained no information which indicates that these requirements are not achievable.

It should be noted that the design guidelines are directed primarily at the traditional two stage starved-air hospital waste incinerators. This does not preclude the use of rotary kiln combustors or municipal waste incinerators to burn infectious waste.

MT:SK:sb/3197E

cc: J. Rickun - AM/3
D. Packard - AM/3
P. Didier - SW/3
R. Renaud - SW/3

Wisconsin Department of Natural Resources
Bureau of Air Management

Draft Guidelines for Infectious Waste Incinerators

April 22, 1988

The following guidelines are for incinerators used to treat infectious wastes. These guidelines are intended to minimize the potential for adverse public health and environmental impacts due to improper waste handling, excessive stack emissions or improper ash management. Requirements for incinerator design and operation, and air pollution control are established in order to achieve the lowest achievable emission rate for stack pollutants of concern. These guidelines apply to infectious waste incinerators of all sizes.

Issues addressed in these guidelines include:

A. Definition of Infectious Wastes
B. Incinerator Design and Operation
C. Ash Handling and Quality
D. Stack Design
E. Waste Handling Procedures
F. Air Pollution Control Requirements
G. Performance Monitoring and Testing
H. Operator Qualifications

A. Definition of Infectious Wastes

Infectious wastes are defined under s. NR 500.03(67), Wis. Adm. Code, to be: "A solid waste which contains pathogens with sufficient virulence and quantity so that exposure to the waste by a susceptible host could result in an infectious disease".

Typical hospital and health care facility wastes which may be considered infectious are:

1. Microbiological laboratory wastes including cultures and equipment which has come in contact with cultures of infectious agents;

2. Blood, blood products and bodily fluids including those from dialysis units;

3. Sharps including needles, laboratory glass wastes and glass pipets;

4. Surgical, autopsy and obstetrical wastes which have had contact with patient blood or body fluids;

5. Wastes which have had contact with communicable disease isolation wastes; and

6. Human and animal tissue containing pathogens with sufficient virulence and quantity so that exposure to the waste by a susceptible human host could result in an infectious disease.

B. Incinerator Design and Operation

1. Waste Charging

The waste charging system of any infectious waste incinerator shall be designed so large amounts of air cannot enter the furnace and disrupt the combustion process as waste is charged. This may include a lockout mechanism on batch fed units to prevent charging after start-up, or a ram feed system equipped with a closing and virtually air tight lid.

2. Auxiliary Burners

a. The primary waste burning chamber or zone shall be equipped with an adequately sized auxiliary fuel burner to:

   1) Ignite waste in a batch fed unit;

   2) Preheat the chamber up to operating temperatures on a continuously fed unit; and

   3) Maintain minimum chamber temperatures while wastes are burned.

b. Any secondary combustion chamber or combustion zone shall be equipped with an adequately sized auxiliary fuel burner to maintain required combustion temperatures.

3. Residence Times and Operating Temperatures

All infectious waste incinerators shall be equipped with a secondary combustion chamber or combustion zone which provides for a minimum of two seconds residence time at 1800°F or greater after turbulent mixing with secondary combustion air to minimize trace organic and visible emissions.

4. Start-Up Procedures

a. Batch fed infectious waste incinerators shall be designed and operated so that during start-up:

   1) Precautions are taken to avoid charging the incinerator above its capacity;

   2) The waste is ignited with an auxiliary fuel burner;

   3) The secondary combustion chamber or combustion zone is preheated to at least 1800°F before waste ignition;

4) There is no further waste charging after waste ignition;

5) There is an automatic lockout of the charge door after the waste is ignited to allow for sufficient time to allow complete burnout of the waste.

b. Continuous feed infectious waste incinerators shall be designed and operated so that during start-up:

1) The primary waste burning chamber is brought up to the operating temperature prior to charging waste;

2) The secondary combustion chamber or combustion zone is preheated to at least 1800°F; and

3) There is an automatic lockout mechanism which prevents charging if primary or secondary combustion chamber or combustion zone temperatures fall below design levels.

5. Shutdown Procedures

Every incinerator shall be designed so that during shutdown the secondary combustion chamber or combustion zone temperature is maintained above 1800°F until the waste is completely burned.

C. Ash Handling and Quality

1. Ash Handling

All ash removal from the incinerator shall occur in an enclosed area. There shall be no visible emissions to the outside air when ash is removed from the facility or during transport to the ash disposal site. Ash shall be completely enclosed during transport.

2. Ash Quality

All incinerated waste shall be "completely burned" per Sec. NR 506.11, Wis. Adm. Code, such that the fixed carbon content does not exceed 5%, by weight, by proximate analysis, and there are no visible unburned combustibles.

D. Stack Design

1. Stack Height

All incinerator stacks shall be located and of sufficient height to assure compliance with applicable air standards, and to avoid the flow of stack pollutants into any building ventilation intake plenum.

2. Emergency (Dump) Stack

Any stack which emits incinerator pollutants prior to the air pollution control shall not be used when waste is burning, except to protect the air pollution control equipment during unavoidable malfunctions.

E. Waste Handling Procedures

1. Any waste designated as infectious waste under these guidelines, if delivered to an incinerator from another facility, shall be double bagged in red plastic bags and boxed in leak-proof corrugated cardboard. The outside container should be labelled with a visible biohazard emblem. Packaging integrity must be maintained until burning.

   A single bag which meets the ASTM 165 gram dart drop test (Method D-1709-75) may be substituted for the double bags. Rigid reusable leak-proof containers may be substituted for the cardboard boxes.

   Sharps shall be transported in puncture-proof containers.

2. All infectious waste containers transported to another facility shall be enclosed in vehicles.

3. Any infectious waste transported to the incinerator from another facility shall be refrigerated below 42°F if the time between packaging and burning exceeds 92 hours.

4. All carts and reusable equipment used for transporting infectious waste shall be steam cleaned after each use. Water drained from these operations shall be disposed of in a sanitary sewer.

5. No infectious waste shall be stored outside where it is exposed to the elements or accessible to the general public.

F. Air Pollution Control Requirements

1. Total Suspended Particulates (TSP)

   a. All incinerators with a capacity of 1000 pounds per hour or greater shall be equipped with control equipment to comply with a TSP emission limitation of 0.01 grains per dry standard cubic foot corrected to 7% O_2, including condensible TSP.

   b. All incinerators with a capacity of 200 pounds per hour or greater shall be equipped with control equipment to comply with a TSP emission limitation of 0.02 grains per dry standard cubic foot corrected to 7% O_2, including condensible TSP.

c. All incinerators with a capacity less than 200 pounds per hour and 4,800 pounds per day shall comply with a TSP emission limitation of 0.06 grains per dry standard cubic foot corrected to 7% O_2, including condensible TSP.

d. The inlet temperature to any particulate control equipment shall not exceed 300° F.

2. Hydrogen Chloride (HCl) - All incinerators with a capacity of 200 pounds per hour or greater shall be equipped with control equipment to comply with an HCl emission limitation of 50 parts per million dry volume corrected to 7% O_2 over any continuous one hour period.

3. Carbon Monoxide (CO) - All incinerators shall not exceed a CO emission limitation of 75 parts per million dry volume corrected to 7% O_2 over any continuous three hour period.

4. Stack Flue Gas Opacity - All incinerators with a capacity of 200 pounds per hour or greater shall not exceed 5% opacity as measured by U.S. EPA Method 9.

G. Performance Monitoring and Testing

1. Temperature Monitoring - All incinerators shall be equipped to continuously monitor and record representative operating temperatures in the primary combustion chamber and the exit of the secondary combustion chamber or combustion zone.

2. Stack Tests - Every incinerator shall be stack tested for TSP, HCl and CO during the initial shakedown period after construction, and every two years thereafter. These tests shall include a determination of the emissions of Arsenic, Cadmium, Total Chromium, Lead and Nickel.

3. Records shall be kept of the weight of waste charged to the incinerator each day.

4. Ash Tests - During the shakedown period after construction there shall be a verification of compliance with the burnout requirements (visible combustibles) of s. NR 506.11, Wis. Adm. Code and ash management requirements of s. NR 502.09, Wis. Adm. Code.

H. Operator Qualifications

1. A trained incinerator operator shall be present at the facility in which an incinerator is located whenever waste is being burned.

2. Operator training shall include a program of study approved by the Department prior to air permit issuance or renewal. This program shall include:

a. Proper waste handling procedures;

b. Identification of waste types acceptable for incineration;

c. Incinerator design and waste combustion theory;

d. Proper incinerator start-up, operation, shutdown, and maintenance procedures;

e. Work safety procedures, including infectious disease control procedures for the facility;

f. Applicable air pollution, solid waste, and wastewater management regulations;

g. Air pollution control equipment operation and maintenance; and

h. A minimum of 24 hours of hands-on incinerator operation under the supervision of another trained operator or the incinerator manufacturer's representative.

3. Operator training shall include a review of incinerator operation and maintenance procedures every year. This review shall last eight hours or more and its content approved by the Department.

4. Every operator shall have visible proof of completion of the required initial training and annual review posted near the incinerator equipment.

3197E

HOSPITAL WASTE MANAGEMENT IN CANADA

David Campbell
Department of Environment

Presented at:

HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP

Golden Gateway Holiday Inn
San Francisco, CA
May 10-12, 1988

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SPEAKING NOTES

MR. CHAIRMAN, LADIES & GENTLEMEN.

AS STATED, MY TOPIC IS HOSPITAL WASTE MANAGEMENT IN CANADA.

I PLAN TO ADDRESS THIS SUBJECT BY GIVING A GENERAL OVERVIEW OF 2 AREAS IN WHICH ENVIRONMENT CANADA IS WORKING WITH THE PROVINCES IN THIS FIELD.

THE 1ST AREA IS A STATE OF THE ART REPORT AND CODE OF PRACTICE ON BIOMEDICAL WASTES.

THE 2ND AREA IS A HOSPITAL WASTE INCINERATOR TESTING PROGRAM IN WHICH WE ARE PRESENTLY COMPLETING THE FIRST PHASE.

BUT FIRST I PREFER TO START A SUBJECT SUCH AS THIS, BY CENTERING DOWN ON WHERE THIS WASTE PROBLEM RELATES TO THE OVERALL WASTE PROBLEM IN CANADA.

IF WE LOOK AT SLIDE 1.

SLIDE 1 WASTE GENERATION IN CANADA

THE QUANTITY OF BIOMEDICAL WASTES IS SMALL BUT IF ONE CONSIDERS THAT THESE WASTES ARE GENERATED IN HEALTH CARE FACILITIES, THEN THEIR IMPORTANCE FAR EXCEEDS THEIR NUMBER.

FROM THE POINT OF VIEW OF AN INCINERATOR ENGINEER WE USED TO VIEW HOSPITAL WASTE IN 4 CATEGORIES:

(1) KITCHEN WASTES
(2) GENERAL WASTES (OFFICES, WAITING ROOMS, ETC.)
(3) ANATOMICAL WASTES (TISSUE)
(4) PATHOLOGICAL WASTES (INFECTIOUS WASTES)

BIOMEDICAL WASTES ARE COMPOSED OF THE LAST 2 CATEGORIES AND REPRESENT ABOUT 10% OF HOSPITAL WASTES.

FROM A PRACTICAL POINT OF VIEW MANY HOSPITALS HAVE DIFFICULTY EFFECTIVELY SEPARATING THESE WASTES SO THAT BIOMEDICAL WASTES CAN CONTAIN A LOT OF NON-INFECTIOUS WASTES.

IN 1986 ENVIRONMENT CANADA COMPLETED A STATE OF THE ART REPORT ON BIOMEDICAL WASTES AND IN THE REPORT, GENERATORS AND GENERATION RATES ARE COVERED.

SLIDES 2, 3 & 4 SHOW HOW HOSPITAL WASTES ARE DETERMINED.

SLIDE 2 HOSPITAL DISTRIBUTION IN CANADA
SLIDE 3 HOSPITAL WASTE GENERATION RATES
SLIDE 4 BIOMEDICAL WASTE GENERATION IN CANADA

THESE TABLES REPRESENT HOW OUR DATA BASES ARE OBTAINED.

IN SUMMARY THEN, WE ARE DEALING WITH 20,000 TONNES/YEAR OF BIOMEDICAL WASTE FROM HOSPITALS OR APPROXIMATELY 10% OF WASTE GENERATED AT A HOSPITAL.

THE STATE OF THE ART REPORT ALSO DEALS WITH CURRENT MANAGEMENT PRACTICES IN CANADA.

THE AUTHORS HAD DIFFICULTY OBTAINING GOOD DATA IN THIS AREA, BECAUSE MANY JURISDICTIONS INCLUDE HOSPITAL WASTE IN WITH THE GENERAL WASTES.

HOWEVER, THERE ARE GOOD EGS, WITHIN REGIONS WHICH PROVIDE US WITH A GOOD IDEA OF HOW THESE WASTES ARE MANAGED.

IN THE PROVINCE OF ALBERTA A RECENT STUDY PROVIDED DATA ON HOSPITAL WASTE MANAGEMENT WHICH IS SHOWN IN SLIDE 5.

SLIDE 5 ALBERTA HOSPITAL WASTE SURVEY

THESE DATA POINT TO PRACTICES AND ATTITUDES TOWARDS HOSPITAL WASTE MANAGEMENT THAT ARE WORTH NOTING.

FIRST, AUTOCLAVING, A SEEMING PANACEA FOR INFECTIOUS WASTES IS VERY LITTLE USED.

SECOND, THERE IS EXTENSIVE LANDFILLING OF BIOMEDICAL WASTE.

ALTHOUGH ALL AREAS ARE NOT THE SAME IN CANADA, IN GENERAL WE CAN EXPECT SIMILAR PRACTICES ACROSS THE COUNTRY.

THE LAST SECTIONS OF THE REPORT COVER THE BEST MANAGEMENT TECHNOLOGIES AND RECOMMENDATIONS. THESE ARE CONSIDERED UNDER 4 HEADINGS AS SHOWN IN SLIDE 6.

SLIDE 6 **HOSPITAL WASTE WORKSHOP**

UNDER THE FIRST HEADING - ON-SITE HANDLING.
THE VARIOUS PRACTICES WERE DISCUSSED FOR BAGGING AND MOVING BIOMEDICAL WASTES WITHIN THE HOSPITAL PERIMETER.

ALTHOUGH THERE ARE MANY IMPORTANT PRACTICES IN THIS AREA, ONE NEED STOOD OUT.

THE NEED FOR COLOUR-CODED BAGS AS SHOWN IN SLIDE 7.

SLIDE 7 **COLOUR CODING FOR BIOMEDICAL WASTE**

COLOUR CODING OF BAGS IS IMPORTANT BECAUSE IT WOULD INCREASE SAFETY, PARTICULARLY IF THERE IS MORE MOVEMENT TOWARDS REGIONAL INCINERATORS, WHICH APPEARS TO BE THE TREND.

THIS TREND WILL RESULT IN A GREATER NUMBER OF PEOPLE HANDLING THE WASTES PRIOR TO DISPOSAL AND WILL INCREASE THE RISK OF EXPOSURE.

IN ADDITION, AN ACCIDENT EN ROUTE COULD SPILL THESE WASTES ON THE HIGHWAY AND EXPOSE CLEAN-UP CREWS TO DANGERS.

THE USE OF COLOUR-CODED BAGS WOULD REDUCE THESE DANGERS.

THE NEXT HEADING IS ON-SITE TREATMENT AND DISPOSAL.

HERE, AUTOCLAVES, CHEMICAL DISINFECTION, IRRADIATION, GRINDING AND INCINERATION WERE DISCUSSED.

THE NEEDS THAT WERE EXPRESSED IN THIS AREA WERE FOR:

1) AN AGREEMENT ON THE USE OF THE SANITARY SEWER FOR DISPOSAL OF LIQUID BIOMEDICAL WASTES;

PRESENTLY, SOME JURISDICTIONS ALLOW DISCHARGE TO THE SEWER, WHILE OTHERS ARE NOW CALLING FOR DISINFECTION PRIOR TO DISCHARGE.

2) AN AGREEMENT IS NEEDED ON THE USE OF THE "HOT HEARTH" INCINERATORS FOR ANATOMICAL WASTES UNTIL ALTERNATIVES ARE PROVEN SAFE.

SLIDE 8 HOT HEARTH INCINERATOR
SLIDE 9 COMPARISON OF TYPE 1 AND TYPE 4 WASTE

IN MOST JURISDICTIONS, THESE INCINERATORS CONTINUE TO OPERATE, ALTHOUGH PROBLEMS HAVE ARISEN DUE TO THE BURNING OF NON-ANATOMICAL WASTES IN "HOT HEARTH" INCINERATORS.

ALSO, ANATOMICAL WASTES HAVE BEEN CHARGED DIRECTLY INTO THE NEWER CONTROLLED-AIR INCINERATORS AND SO FAR, THIS HAS NOT BEEN PROVEN SAFE.

SLIDE 10 CONSUMAT UNIT

THE ROYAL JUBILEE HOSPITAL IN VICTORIA HAS A CONTROLLED-AIR INCINERATOR RATED AT AROUND 2000 LBS/HR.

IT WAS TESTED IN 1980 FOR BACTERIAL ACTIVITY IN THE RESIDUE, AFTER A TEST-BURN WHICH INCLUDED CHARGING ANATOMICAL WASTES.

THE RESULTS OF FOUR TESTS WERE INCONCLUSIVE.

ALTHOUGH THE PRACTICE WAS NOT CONDONED, IT WAS NOT REJECTED EITHER, BY THE DATA.

THEREFORE, THE NEED EXISTS TO FURTHER THESE STUDIES TO DETERMINE IF THE CONTROLLED-AIR INCINERATOR CAN SAFELY ACCOMMODATE BOTH ANATOMICAL AND PATHOLOGICAL WASTES.

THE THIRD HEADING IS TRANSPORTATION OFF-SITE.

CONSIDERABLE HEAT WAS GENERATED OVER WHETHER INFECTIOUS WASTES WERE BEING TRANSPORTED OFF-SITE FOR DISPOSAL.

SOME PARTIES MAINTAINED THAT HOSPITALS DISINFECTED ALL WASTES PRIOR TO TRANSPORT.

OTHERS REALIZED THAT THEY WERE BEING EXPORTED BECAUSE THEY WERE INFECTIOUS WASTES.

IN ADDITION, THE DEFINITION OF BIOMEDICAL WASTE VARIED FROM HOSPITAL TO HOSPITAL AND THEY DID NOT DIRECTLY MESH WITH THE DEFINITION OF INFECTIOUS WASTE UNDER THE TDGR.

AS A RESULT, TWO NEEDS EMERGED:

1) The need for a common definition of Biomedical wastes for hospitals.

2) The need to ensure that Biomedical wastes transported off-site follow the TDGR.

(This latter need is now being met as pathological and infectious hospital wastes are being considered for possible inclusion as a "waste type" in the amendments to the TDGR).

The final heading is Off-Site Treatment and Disposal.

The three methods landfill, sanitary sewer and regional incinerators were reviewed and discussed.

Considerable controversy surrounds the use of landfills and sanitary sewers for the disposal of Biomedical Wastes.

Proponents argue that pathogens do not survive more than 24 hours in a landfill site and that there is no recorded injury from this practice.

Critics are equally adament that scavangers could pick up infectious materials before they are buried and endanger the public.

Because of this debate, there is a need for guidelines on the proper use of landfills and sewers for biomedical wastes backed by information on the safety of these practices.

THE REGIONAL INCINERATOR DEBATE IS NO LESS HEATED.

THESE INCINERATORS WILL DIFFER FROM THE ON-SITE UNITS IN THAT THEY WILL PROBABLY BE MUCH LARGER AND WILL REPRESENT A POTENTIALLY SIGNIFICANT SOURCE OF POLLUTANTS.

A COMPARISON OF HOSPITAL WASTES VS. MUNICIPAL WASTES IS SHOWN IN SLIDE 11.

SLIDE 11 HOSPITAL VS MUNICIPAL WASTE

THE HIGH LEVEL OF PLASTICS, GENERATE HIGH EMISSION LEVELS OF HYDROGEN CHLORIDE.

THEY WILL ALSO INCREASE THE EMISSIONS OF DIOXINS AND FURANS.

HOWEVER, THERE IS VERY LITTLE DATA ON EMISSION RATES FROM INCINERATORS WITH GAS-SCRUBBING EQUIPMENT.

THE ROYAL JUBILEE HOSPITAL IN VICTORIA (WHICH DOESN'T HAVE SCRUBBERS) EMITTED HCL LEVELS AVERAGING 1200 PPM.

AND

THE DECOM INCINERATOR IN GATINEAU QUEBEC WAS ABOVE 700 PPM HCL. (IT DOESN'T HAVE SCRUBBERS EITHER).

PRESENT GUIDELINES ARE BETWEEN 100-500 PPM AND FUTURE GUIDELINES WILL CALL FOR LEVELS WELL BELOW 100 PPM.

THIS WILL MEAN THAT FUTURE HOSPITAL WASTE INCINERATORS WILL PROBABLY REQUIRE GAS SCRUBBERS.

ALSO DIOXIN AND FURAN LEVELS WERE ABOVE 200 NG/M^3 AND NEW STANDARDS ARE PROPOSING LEVELS AT .50 NG/M^3. (TEF NEW INTERNATIONAL METHOD)

SLIDE 12 STACK DISCHARGE LIMITS

SLIDE 12 GIVES THE PROPOSED STACK DISCHARGE LIMITS FOR MUNICIPAL WASTE INCINERATORS IN CANADA. HAZARDOUS WASTE INCINERATORS WILL BE SIMILAR.

IN LINE WITH THESE NEW REGULATIONS WHAT WE WOULD LIKE TO KNOW, AS A FORERUNNER TO THE NEW REGIONAL HOSPITAL INCINERATORS, IS THE LEVELS OF DIOXIN AND FURAN FROM THESE CONTROLLED-AIR INCINERATORS WITH GAS-SCRUBBING EQUIPMENT.

THIS WILL ENABLE US TO BETTER DESIGN AND REGULATE FUTURE INCINERATORS.

BASICALLY, THAT'S THE PROBLEM THAT WE ARE CONFRONTED WITH. THE QUESTION THAT REMAINS TO BE ANSWERED IS "WHAT ARE WE GOING TO DO ABOUT IT?"

SLIDE 13 GIVES A SUMMARY OF THESE NEEDS.

SLIDE 13 SUMMARY

THE FIRST THREE NEEDS SHOWN HERE ARE GOING TO BE MET BY A NATIONAL CODE OF PRACTICE ON THE MANAGEMENT OF BIOMEDICAL WASTES.

Terms of reference for this code have been submitted to the Canadian Council of Resource and Environment Ministers (CCREM) Waste Committee and a decision will be taken in June on the course that this study will take.

It will either be completed by one of 2 ways.

The first involves doing the work in-house by Environment Canada, using a policy steering group made up of members from the provinces and members from institutions such as the Canadian Hospital Association.

The second method would entail employing the services of a standards organization, such as the Canadian Standards Association, or CSA as it's commonly known to act as the facilitator in place of Environment Canada.

This latter route tends to be favoured by Governments since an independent third party facilitator allows each agency to express itself more fully without "stepping on the toes" of the work of a sister agency.

However, that awaits a decision which will be taken in June. The normal time period for this Code to see the light of day would be 2 years.

The fourth need is for additional incinerator performance data.

In this area we are involved in two projects. The first is the testing of the Decom Incinerator plant in Gatineau Quebec.

Here, Environment Canada is assisting Quebec in analyzing the Organic Component of the stack sample as part of the Decom compliance test.

Decom burns Biomedical waste from the U.S. (50%) Ontario (40%) and Quebec (10%).

The incinerator being tested is a 600 kg/hr Simons controlled-air incinerator (Simons is out of Florida).

It was modified to include a flakt dry scrubber after failing to meet Quebec's emissions standards without a scrubber.

The results of these tests will be available by the fall of this year, and will consist of the data shown on slide 14.

SLIDE 14 DECOM EMISSION DATA

The second project is the optimization testing of one of three incinerators which we have classified as regional incinerators.

All of these incinerators have control equipment and are shown on slide 15.

SLIDE 15 INCINERATOR CANDIDATES

THE TESTS WILL DIFFER FROM THE NORMAL COMPLIANCE TESTING IN THAT COMBUSTION CONDITIONS WILL BE VARIED TO ACHIEVE OPTIMUM OPERATING CONDITIONS THAT MINIMIZE POLLUTANT EMISSION LEVELS SIMILAR TO THE NITEP TESTING PROGRAM.

A SUBMISSION HAS BEEN MADE FOR FUNDS TO COMPLETE THIS WORK WHICH IS PROJECTED TO BEGIN AT THE END OF THIS YEAR FOLLOWING COMPLETION OF THE GROUNDWORK.

SLIDE 16 CONCLUSION

SO IN SUMMARY, WE ARE LOOKING AT A 2-3 YEAR PERIOD IN WHICH WE PLAN ON OBTAINING EMISSION DATA ON HOSPITAL WASTE INCINERATORS WITH SCRUBBERS AND A NATIONALLY ACCEPTED CODE OF PRACTICE ON THE HANDLING, TREATMENT AND DISPOSAL OF BIOMEDICAL WASTES.

THAT CONCLUDES MY REMARKS ON HOSPITAL WASTE MANAGEMENT IN CANADA.

WASTE GENERATION IN CANADA
KILOTONNES/YR

SECTOR	GENERATED
MINE TAILINGS	600,000
AGRICULTURE	40,000
MUNICIPAL	10,000
INDUSTRIAL	60,000
(WOOD)	(30,000)
(SOL.&LIQ.)	(30,000)
(HAZ.)	(3,280)
(HOSP.)	(20)

HOSPITAL DISTRIBUTION IN CANADA

PROVINCES	TOTAL INST.	TOTAL BEDS
YUKON & NWT	4	181
BC	133	21 039
ALBERTA	160	19 531
SASK.	157	7 622
MANITOBA	85	8 196
ONTARIO	303	62 713
QUEBEC	237	48 310
NB	37	5 531
NFLD. & LAB.	35	3 665
NS.	49	5 665
P.E.I.	9	947
TOTAL	1 189	183 400

HOSPITAL WASTE GENERATION RATES

WASTE TYPE	SOURCES	GENERATION RATE
GENERAL	AMERICAN	(1)4.98 K/PAT./DAY (2)4.34 K/BED/DAY
	CANADIAN	(1)3.59 K/PAT./DAY (2)2.92 K/BED/DAY
BIOMEDICAL		(1)0.43 K/PAT./DAY (2)0.3 K/BED/DAY (3)10% TOTAL WASTE

BIOMEDICAL WASTE GENERATION IN CANADA TONNES/YR

SOURCES	GENERATED
HOSPITALS	20,000
OTHERS	
-VETERINARY	1,200
-MEDICAL LABS.	1,500
-RESEARCH LABS.	1,600
TOTAL BIOMEDICAL	25,000
TOTAL HAZARDOUS	3,280,000
% BIOMEDICAL	0.6

ALBERTA HOSPITAL WASTE SURVEY
24 URBAN HOSPITALS

PROCESS	ACTIVITY	PERCENT
1) HANDLING	1) DOUBLE BAG BIOMEDICAL	54%
	2) AUTOCLAVE DRESSINGS ETC.	4%
	3) SEGREGATE SHARPS	46%
	4) SEGREGATE COMBUSTIBLES	54%
2)DISPOSAL	1) INCINERATE COMBUSTIBLES	50%
	2) INCINERATE CONTAMINATED ONLY	4%
	3) LANDFILL ALL WASTES	33%

HOSPITAL WASTE

1) ON-SITE HANDLING

2) ON-SITE TREATMENT & DISPOSAL

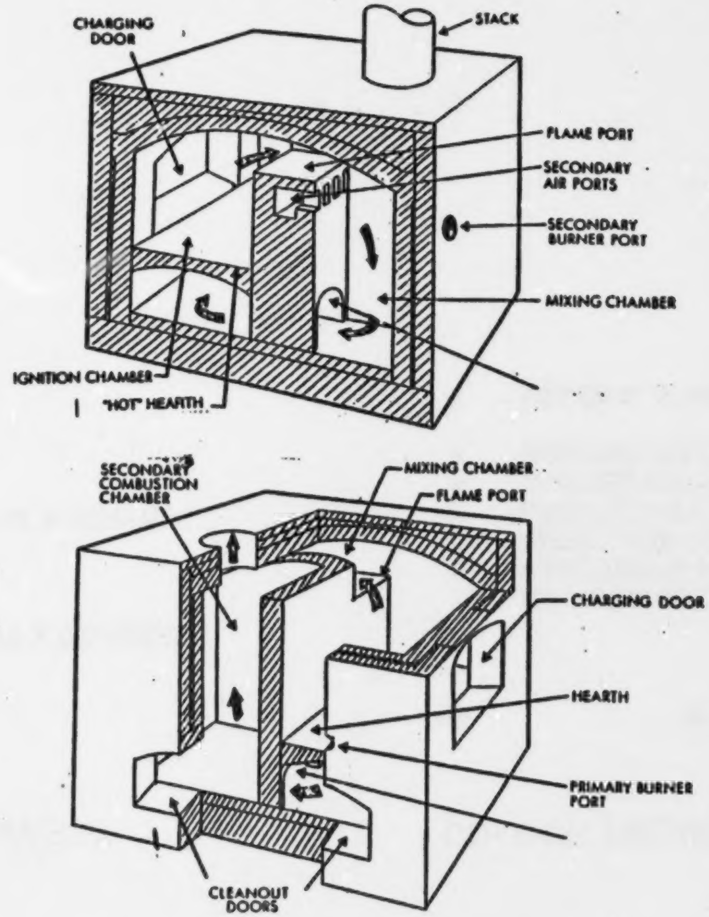
3) TRANSPORTATION

4) OFF-SITE TREATMENT & DISPOSAL

COLOUR CODING FOR BIOMEDICAL WASTE

No.	DESCRIPTION	COLOUR CODING
1	HUMAN ANATOMICAL	RED
2	INFECTIOUS ANIMAL ANATOMICAL	ORANGE
3	INFECTIOUS NON-ANATOMICAL	YELLOW
4	LABORATORY WASTES	YELLOW
5	WASTES FROM DNA WORK	YELLOW
6	NON-INFECTED ANIMAL ANATOMICAL	BLUE
7	GENERAL WASTE	BLACK

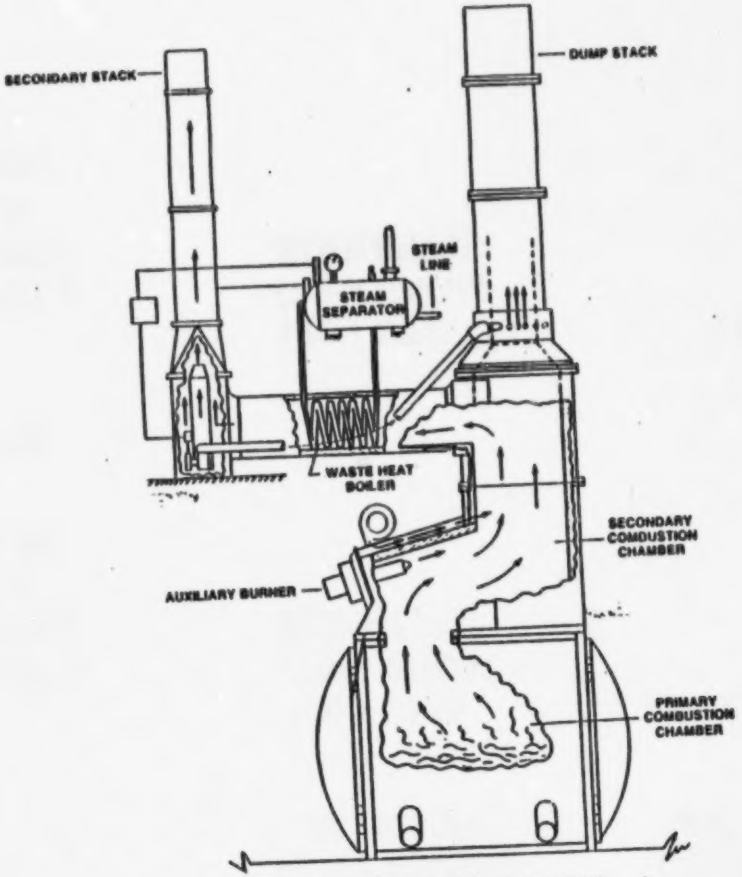
Retort Type Multiple-Chamber Pathological Waste Incinerator


CHARGING DOOR
STACK
FLAME PORT
SECONDARY AIR PORTS
SECONDARY BURNER PORT
MIXING CHAMBER
IGNITION CHAMBER
"HOT" HEARTH
SECONDARY COMBUSTION CHAMBER
MIXING CHAMBER
FLAME PORT
CHARGING DOOR
HEARTH
PRIMARY BURNER PORT
CLEANOUT DOORS

Side View

COMPARISON OF TYPE 1 & 4 WASTE

TYPE 1 WASTE	VOLUME OF FLUE GASES AT 1600°F	THEORETICAL COMBUSTION AIR AT 70°F	TOTAL AIR REQ'D FOR COMBUST. 70°F
100 LB/HR (65% COMBUST.) (10% MOISTURE) (1000 BTUS/LB FROM BURNER)	1200 CFM (20% FROM BURNERS)	75 CFM	250 CFM
TYPE 4 WASTE			
100 LBS/HR (10% COMBUST.) (85% MOISTURE) (8000 BTUS/LB FROM BURNER)	1200 CFM (75% FROM BURNERS)	11 CFM	100 CFM


SECONDARY STACK
DUMP STACK
STEAM LINE
STEAM SEPARATOR
WASTE HEAT BOILER
SECONDARY COMBUSTION CHAMBER
AUXILIARY BURNER
PRIMARY COMBUSTION CHAMBER

GAS FLOW IN STEAM PRODUCTION SYSTEM
SILOAM SPRINGS, ARKANSAS

HOSPITAL VS MUNICIPAL WASTE
%

WASTE TYPE	HOSPITAL	MUNICIPAL
1) DRY CELLULOSIC SOLIDS	45.1	54.2
2) WET CELLULOSIC SOLIDS	18.0	12.2
3) PLASTICS	14.2	7.4
4) RUBBER	0.7	
5) NON-COMBUSTIBLES	20.4	26.2
6) PATHOLOGICAL	1.6	
TOTAL	100%	100%
HEAT VALUE	6000 BTUS/LB	4335 BTUS/LB

CONCLUSIONS

1) NATIONAL DEFINITION REQ'D

2) COLOUR CODING OF BAGS REQ'D

3) POLICY ON DISCHARGE TO LANDFILLS & SEWERS

4) ADDIT'L INCINERATOR PERFORMANCE DATA

DECOM TESTING PROGRAM

ANALYSIS FOR DIOXINS, FURANS, PCBs, CHLOROBENZENES, CHLOROPHENOLS AND BENZO-A-PYRENE (AS A SURROGATE FOR POLYAROMATIC HYDROCARBONS).

SOURCE	PROCEDURE	No. OF SAMPLES
GAS	THREE MM5 SAMPLE TRAINS ONE MM5 BLANK TRAIN	3 FILTER & RESIN (COMPOS.) 3 IMPINGERS 1 BLANK TRAIN (COMPOS.)
BOTTOM ASH	COMPOSITE OF SAMPLES TAKEN DURING EACH TEST	3
FLY ASH	COMPOSITE SAMPLE COLLECTED DURING EACH TEST	3
QUENCH WATER	SAMPLE COLLECTED DURING EACH TEST	3

INCINERATOR CANDIDATES

NAME (LOCATION)	TYPE	AIR POLLUTION CONTROL	CAPACITY (kg/h)
DECOM (GATINEAU, QUEBEC)	CONTINUOUS CHARGE CONTROLLED AIR	BOILER & FLAKT SCRUBBER	600
FOOTHILLS (CALGARY, ALBERTA)	CONTINUOUS CHARGE CONTROLLED AIR	BOILER AND SCRUBBER	1135
UNIV. OF ALBERTA HOSPITAL (EDMONTON, ALBERTA)	ROTARY KILN	BOILER AND SCRUBBER	2 × 600

CONCLUSIONS

1) COMPLIANCE TESTING OF DECOM INCINERATOR
2) OPTIMIZATION TESTING OF A REGIONAL BIOMEDICAL WASTE INCINERATOR
3) CODE OF PRACTICE ON THE HANDLING, TREATMENT & DISPOSAL OF BIOMEDICAL WASTES

SESSION IV: TOPICS OF SPECIAL CONCERN: PATHOGEN SURVIVAL, RISK ASSESSMENTS, AND REGIONAL FACILITIES

SUMMARY OF DISCUSSION (SAN FRANCISCO)

Q: **How are additive risks considered?**

A: **(J. Held, NJ DEP) Some agencies do not consider additive risks. They are difficult to define and assess objectively, so judgments must be made. For example, a long list of risks which are just under $1:10^{-6}$ is less comfortable than a long list of risks which are $1:10^{-13}$.**

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SESSION IV: TOPICS OF SPECIAL CONCERN -- PATHOGEN SURVIVAL, RISK ASSESSMENTS, AND REGIONAL FACILITIES

SUMMARY OF DISCUSSION (BALTIMORE)

Q: In comparing risks, the effects of metals should be included. They may be a greater concern than dioxins.

Q: Waste management is needed at each stage. According to newspaper reports, hospitals have succeeded in recycling some materials.

A: (D. Painter, EPA) Recycling may work in theory, but separation of wastes may be too onerous a task to expect from the staff to whom it is likely to be assigned, i.e. overworked and underpaid nurses.

Q: One second at 1800° F should not be a performance standard since it does not account for turbulence. "Four 9's" were achieved in RCRA tests of a well-designed industrial incinerator with fluidized-bed combustion.

Q: How is 0_2 monitoring used to control combustion? Is it used as a secondary parameter (after temperature) for controlling air input and burner operation?

A: (S. Shuler, Ecolaire Corp.) Current technology is based on temperature, but research is in progress toward using other parameters, possibly 0_2 and CO.

Q: To develop an approach to regulating HCl, Texas considered corrosion impacts due to Cl in coastal areas. Ambient monitoring of Cl on the coast indicated concentrations of 2-3 ug/m^3, so the Texas ACB is using a judgmentally established standard of 0.1 ug/m^3.

A: (J. Lauber, NY DEC) New York has commented on EPA's revised draft RCRA regulations, which specify an annual average of 15 ug/m^3 for Cl.

Q: Performance tests should not be relied on uncritically because the constituents of the waste usually are unknown. Instead, one should emphasize fully modulated burners (more generally, full combustion modulation of secondary chamber burners, not just cutback of air), instrumentation, incinerator maintenance, maintenance of monitors, and good air pollution controls.

Q: How do New Jersey DEP data on impacts of hospital waste incinerators compare with the impacts of municipal or hazardous waste incinerators?

A: (J. Held, NJ DEP) New Jersey DEP has not made a formal comparison, but As, Cd, Cr, and Ni from hospital incinerators appear to be roughly 2 orders of magnitude less than from municipal incinerators. For dioxins, the risks are about the same, with slightly less risk from municipal incinerators.

Q: How is population exposure considered? For example, municipal incinerators are usually located outside of town, while hospital incinerators are near a population of sick patients.

A: (J. Held, NJ DEP) New Jersey DEP did not consider exposure of subgroups because everyone deserves the same protection. But in the future the agency may consider acute effects and apply larger safety factors for short term exposure of sensitive populations, especially for HCl and NO_x.

SESSION V

AGENCY PERMITTING EXPERIENCES

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PRESENTATION OF EMISSION DATA AND DISCRIPTION OF AIR QUALITY IMPACTS FROM HOSPITAL INCINERATORS

Lynn Fiedler
Michigan Department of Natural Resources
Air Quality Division

Presented at:

HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP

Golden Gateway Holiday Inn
San Francisco, CA
May 10-12, 1988

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My name is Lynn Fiedler/ Randy Telesz and I am a senior engineer with the Michigan Department of Natural Resources, Air Quality Division.

Today I am here to discuss our experience in permitting new hospital waste incinerators in Michigan.

In the past the review of a hospital incinerator involved insuring the particulate emissions would not violate the National Ambient Air Quality Standards and determining the PSD increment consumption. The particulate emission limit is 0.2 pounds per 1000 pounds of exhaust gases corrected to 50 percent excess air. We also looked for 1200 F and 1/2 second retention time in the secondary chamber.

In 1986, we began to question whether or not a more in-depth review should be done on hospital incinerators. This was because of our ever increasing knowledge of the toxic emissions from municipal solid waste incinerators and compliance with Michigan's Rule 901.

Our review of municipal waste incinerators indicated that the burning of plastics and paper cause the emission of many potential carcinogens and other toxic pollutants. The waste streams in a hospital tends to be very similar to that of a municipal waste incinerator. The percentage of plastic is much higher in the hospital waste stream. The hospital units tend to have poor combustion due to constant variation in the type of waste being burned and the amount of waste being fed into the unit. These units also tend to have poor dispersion because of short stacks and varying building heights.

(picture) Like this!

Michigan's Rule 901 prohibits the emission of any air contaminant that may cause injurious effects to human health and welfare. In addition, the emission shall not interfere with the comfortable enjoyment of life and property.

Armed with these two points, we entered into phase I of permitting in the Winter of 1986.

About this time we received two applications for large units with heat recovery. Both units were to be located in very large hospitals equipped with tall stacks.

We asked both applicants to demonstrate compliance with Rule 901 by quantifying the emissions from their units. We also asked for a demonstration that 1800 F and a 1 one second retention time could be achieved and maintained. Needless to say the applicants were less than pleased when this information was requested. They were very concerned they were being treated differently and this request would cost them considerable time and money.

To assist them we identified HCl, cadmium, arsenic, chromium, dioxins, and furans as the pollutants of most concern. We chose these pollutants from our review of municipal incinerators. We had found in the our reviews that these pollutants were of a magnitude and toxicity to be of concern.

While the two applicants were busy trying to gather data we continued to investigate the emissions and their impacts. During the spring months we received the Royal Jubilee test and other supporting articles. This information really confirmed our suspicions and renewed our determination to have these applicants address our concerns. With this emission data we also did some dispersion modeling of various sized units.

The dispersion modeling results were not surprising and entered us into Phase two of permitting.

We found the impacts from the smaller units were as high if not higher than the larger units due to lower airflows, shorter stacks, and other problems with dispersion. In July of 1986 we required all units regardless of size to quantify emissions and demonstrate 1800 and 1 second. By now all the applicants and the suppliers were less than pleased. It really amazed us that these health care officials acted no differently and were in many cases appeared more reluctant to address the issue of toxics than their industrial counterparts. In fact, an equipment vendor, on behalf of the permit applicants, took his concerns before the Michigan Air Pollution Control Commission, the permitting authority. The vendor requested the permits be issued with no additional controls or requirements and without addressing the toxics issue. The commission not only denied the request but they directed the Air Quality Division staff to continue to investigate and to work with the hospitals. In January of 1987, we held an informational meeting on hospital incineration and air quality requirements for hospital administrators and equipment vendors. We prepared a report which described the toxic emission problems from hospital incinerators. This report is available. Let me know if you'd like a copy.

Back to phase two. The emission quantification process was not going very well. The data supplied by the applicants and suppliers was quite sketchy and being used in a piecemeal fashion. Some of the applicants argued the average values should be used and the majority insisted the lowest numbers of all the tests represented their proposal. Those who argued the most that their meticulous pre-sorting procedures would result in low emissions were found to have some of the highest HCl levels. To assist the applicants and to insure the worst case operations were represented, our division began to quantify the emissions for permitting the units.

Test data from those tests listed were used. These tests, which represent a range of unit sizes, provided the only data available to us at the time. The data were put into common units and normalized to 12 percent CO_2 for comparison.

The next step was to perform a statistical analysis for each pollutant. The value representing the 95 percentile was selected for use as the emission rate. This means 95 percent of the time the emissions from the unit would be expected to be less than this calculated value and 5 percent of the time they would be expected to be greater. The 95 percentile was selected as a compromise between the 99 percentile used for determining emission rates for municipal incinerators and the mean value the applicants requested. We believed at that time the 95 percentile would provide good protection of the environment and also provide the applicant with an adequate margin of safety for continuous compliance.

For example, 26 data points were used in the hydrogen chloride calculations. They ranged from 170 ppm to 1490 ppm. The 95 percentile value was determined to be 1399 ppm. The mean value for the data was 741 parts per million. The uncontrolled emission rate for HCl from a municipal incinerator is around 100 ppm.

The same procedure was then performed on these pollutants.

As new information is received, the emission rates are revised. This slide shows how the 95 percentile for HCl has increased since the original calculation. We received some test data that was quite high and I will be discussing that test in a couple of minutes.

The emission rates are then used to determine the maximum impacts at ground level and at the air intakes. This is necessary to protect the patients, visitors and the people living near the hospital. The dispersion unit uses a modified Industrial Source Complex model to estimate the maximum impacts within 300 feet of the stack.

This slide illustrates a unit with a tall stack which had poor dispersion because of the hospital configuration.

This is the reason the impact at air intakes and open windows is evaluated.

The impacts are then reviewed to determine if they are environmentally acceptable. In Michigan, an emission which represents a risk of less than 1 in 1 million or is less than one percent of the TLV has been accepted as demonstrating compliance with Rule 901.

Phase 3 began with the permit applicants evaluating the alternatives to reduce the impacts from their proposed units. The alternatives are installing taller stacks or installing control equipment. The third item listed was an option available for the two units which had already completed construction.

Dispersion modeling is done to determine the stack height necessary to reduce the impacts to an acceptable level. As you can see the addition of 33 feet was necessary to reduce the risk from chromium to acceptable levels. Six hospitals have chosen this alternative. In some cases structural limitations do not allow this option.

Three hospitals are planning on installing control equipment to reduce the emissions. Two have chosen wet scrubbers and one applicant is pursuing a dry scrubber/baghouse system.

Two hospitals had completed installation of their unit and were confident the emissions from their units would be much less than the 95 percentile value because of their measures to limit PVC plastic usage and pre-sort the waste. They requested to be allowed to stack test to determine the emissions from their units. We required the highest plastic content, typical waste be burned during testing. The HCl values from one unit tested ranged from 1900 to 2700 ppm. These values are significantly higher than the 1399 ppm predicted. These values were used in recalculating the HCl emission rate.

When a permit is issued the permit conditions specified must be binding to set limits on emissions and operations. They must also be legally enforceable to insure compliance. For these types of units, the emission rates representing the 95 percentile are specified in the permit conditions provided that these rates are environmentally acceptable. We have also been requiring a continuous temperature monitor to insure 1800 F is maintained for a minimum of one second on a one hour average. The temperature shall not drop below 1600 F at any time. The units are required to shut down if the temperature cannot be maintained. The units are also required to use auxiliary fuel to preheat the secondary combustion zone at 1800 F before any waste is added.

Phase 4 is where we are heading now. Currently a committee is working on toxics regulations for all air pollution sources in the state. They hope to be completed this summer. The Departments of Public Health and Natural Resources have set up a committee to draft new hospital incinerator regulations. We are also beginning to set up a testing program for testing toxics from these units.

PERMITTING IN MICHIGAN

MICHIGAN DNR
AIR QUALITY DIVISION

Lynn Fiedler

HISTORIC REVIEW

- Particulates
- 1400 F & 1/2 sec

1986

- Knowledge of MWS
- Rule 901

HOSPITAL WASTE VS. MWS

- Similar Waste
- Poor Combustion
- Poor Dispersion

RULE 901

- Health & Welfare
- Comfortable Enjoyment

PHASE 1 - WINTER 1985/86

TWO APPLICATIONS

- U of Mich (1500 pph)
- St. Mary's (1100 pph)

APPLICATION REQUIREMENTS

- Quantify Emissions
- 1800 F & 1 sec

TOXIC EMISSIONS

HCl
Cadmium
Arsenic
Chromium
Dioxins
Furans

EMISSIONS/IMPACTS

- Royal Jubilee Test
- Articles
- Dispersion

PHASE 2 - JULY 1986

ALL UNITS

Application Requirements

- Quantify Emissions
- 1800 F & 1 sec

Emission Quantification

- Applicants & Suppliers
- Air Quality Division

Test Data

Royal Jubilee
Alta Bates
Illinois
Erlanger
Oak Forest
Queen of the Valley

Statistical Analysis

- 95% Emission Rate
- Margin of Safety
- Protect Environment

HCI Emission Rate (ppmv @ 12% CO2)

95%	1399
Mean	741

Additional Pollutants

Cadmium
Arsenic
Chromium
Dioxins
Furans

Acceptable Concentrations

- Risk of 1 in 1 million
- 1% of TLV

Maximum Impact

Modeling Review

- Ground level
- Air Intakes

Recalculating HCl (ppmv @ 12% CO2)

Date	95%
11/86	1399
5/88	1768

PHASE 3 - ALTERNATIVES

- Taller stacks
- Control equipment
- Additional testing

TALLER STACKS

Chromium Risk Level

Stack Height	Ground Level	Air Intake
35 feet	5	83
68 feet	.6	.9

ADDITIONAL CONTROL

- Wet Scrubber
- Dry Scrubber/Baghouse

ADDITIONAL TESTING

- Worst Case Waste
- High Levels

PERMIT CONDITIONS

- Binding
- Legally Enforceable

PHASE 4 - FUTURE PROJECTS

- Toxics Regulations
- Hospital Incinerator Regulations
- Testing Programs

PERMITTING NEW HOSPITAL WASTE INCINERATORS IN MICHIGAN

Randal Telesz
Michigan Department of Natural Resources
Air Quality Division

Presented at:

HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP

Hotel Belvedere
Baltimore, MD
May 24-26, 1988

AGENDA

Informational Meeting Regarding Hospital Waste Incineration
January 12, 1987
Law Building Auditorium
Lansing, Michigan

INTRODUCTION AND EXPLANATION OF AIR QUALITY REGULATIONS REGARDING HOSPITAL INCINERATORS - Gerald Avery, Supervisor, Permit Section, Air Quality Division, Department of Natural Resources

PRESENTATION OF EMISSION DATA AND DESCRIPTION OF AIR QUALITY IMPACTS FROM HOSPITAL INCINERATORS - Lynn Fiedler, Environmental Engineer, Southeast Permit Unit, Air Quality Division, Department of Natural Resources

DESCRIPTION OF DISPERSION MODELING PROCEDURES FOR HOSPITAL INCINERATORS - Lou Pocalujka, Chief, Air Quality Evaluation Unit, Air Quality Division, Department of Natural Resources

EXPLANATION OF INFORMATION NECESSARY FOR A COMPLETE PERMIT APPLICATION - Randal Telesz, Environmental Engineer, Northwest Permit Unit, Air Quality Division, Department of Natural Resources

SUMMARY OF HAZARDOUS WASTE REGULATIONS PERTAINING TO HOSPITAL INCINERATORS - Kim Paksi, Lab Scientist, Waste Evaluation Unit, Hazardous Waste Division, Department of Natural Resources

SUMMARY AND WRAP-UP - Gerald Avery

QUESTION AND ANSWER SESSION

many other incinerators. The available test data was insufficient to perform statistical analysis for nitrogen oxides, PCBs, and mercury. Sulfur dioxide and arsenic have also been included in the list because of their known presence from incinerating municipal solid waste and their expected presence from incinerating hospital waste. No hospital test data was found on these two pollutants; therefore, values based on municipal waste incineration were used since this is the best available data.

WHAT ARE THE PROJECTED AIR QUALITY IMPACTS ON THE HOSPITAL AIR INTAKES AND GROUND LEVEL?

Answer:

The pollutants which are of major concern, based on the Air Quality Division's analysis, are hydrogen chloride and chromium. The permit review has been completed for the Allegan Hospital in Allegan. Based on the 95th percentile emission rates at the proposed stack height of 35 feet, the hydrogen chloride ground level concentration was slightly higher than the accepted level, and at the air intakes it was projected to be 48.3 times higher. The chromium was 5.1 and 83.0 times the accepted level at ground level and the air intakes, respectively. The upper portion of table 2 includes the impacts for all the pollutants at the original stack height. Dispersion modeling was completed to determine the stack height necessary for the hydrogen chloride and chromium concentrations at both the ground level and air intakes to be less than the accepted level. The stack height was determined to be 68 feet. The bottom portion of table 2 includes the impacts for all the pollutants at the revised stack. Table 3 provides the building heights, original stack heights and the revised stack heights for the hospitals which have provided sufficient information for dispersion modeling.

WHAT IS A DISPERSION MODEL?

Answer:

A dispersion model is a set of equations used to estimate how pollutants emitted from a source will travel and spread with time and distance. To do this, the model must consider:

1. Factors that define the source - such as emission rate, stack height, building height, stack exit temperature and stack exit velocity.

2. Factors that determine where pollutants will travel and how they will spread, such as wind speed, wind direction and the mixing capability of the atmosphere.

The end result is an estimate of the concentration or amount of pollutant, averaged for an interval of time, at a specific point.

HOW IS A DISPERSION MODEL USED IN THE PERMIT PROCESS?

Answer:

A dispersion model is a tool in the permit process. It is used to estimate the impact of a facility on ambient air, prior to the facility being built. The model estimates impact based on design parameters. The predicted impact is compared to a standard or criterion. If the estimated impact is less than the standard, the modeling effort is satisfied. If the estimated impact exceeds the standard, a design change is usually needed to allow the facility to pass a subsequent modeling test.

WHAT ARE SOME OF THE POTENTIAL ALTERNATIVES TO SAFELY DISPOSE OF HOSPITAL WASTE?

Answer:

Ronald A. Drake, Chief, Engineering Plan Review Section, Division of Health Facility Licensing and Certification, Michigan Department of Public Health, has informed the Air Quality Division that hospitals are presently disposing of their solid waste by incineration, landfilling and contracting with commercial incineration firms. Mr. Drake indicated that the majority of small hospitals are currently landfilling their solid waste and that landfilling is an environmentally acceptable method of disposing of these materials. However, there is a concern about the extra handling and transportation of the infectious hospital waste which is associated with landfilling. Therefore, many hospitals are in the process of switching to incineration as the preferred method of disposing of hospital waste. The Air Quality Division believes that the incineration of hospital waste is an acceptable alternative, provided that the hospital incinerator is operated in a manner which provides a retention time of the combustion products of 1 second at a temperature of 1800°F and is equipped with a sufficiently high stack to provide proper dispersion of the emitted air pollutants. The stack must be high enough to prevent the direct impaction of the incinerator emissions into the hospital air intake units and to prevent the downwashing of the incinerator emissions onto the ground level area surrounding the hospital. Installing acid gas scrubbers and bag filter collectors may be a preferred alternative for some of the larger hospital facilities, since installing stacks which conform to good engineering practice heights is quite expensive for incinerators located at hospitals with tall buildings. Other alternatives which merit further study include incineration at municipal resource recovery facilities with air pollution control equipment and at regional hospital incineration facilities which could be located away from the tall hospital buildings. The Air Quality Division has recently met with the Michigan Department of Public Health (MDPH) to discuss the concerns associated with the incineration of hospital waste and the difficulty that the hospital industry is experiencing in permitting new incinerators. As a result of this discussion, a DNR and MDPH task force is currently being established to study and develop recommendations on how hospitals should in the future dispose of their solid waste.

WHAT INFORMATION WOULD THE MICHIGAN AIR POLLUTION CONTROL COMMISSION AND THE AIR QUALITY DIVISION NEED TO PROPERLY EVALUATE THE AIR QUALITY IMPACTS FROM HOSPITAL WASTE INCINERATORS?

Answer:

Rule 203 of the Commission's rules requires a permit applicant to submit a considerable amount of information, some of which includes: (a) the expected composition of the air contaminant stream from a proposed air pollution source; (b) the location and elevation of the emission point and other factors relating to the dispersion and diffusion of the contaminant in the outer air, the relation of the emission point to nearby structures and window openings, and other information necessary to apprise the possible effects of the air contaminant; and (c) data demonstrating the effect of the air contaminant emissions on human health and the environment.

The Air Quality Division has compiled a more specific list of the information that would be necessary to properly evaluate the air quality impact from hospital incinerators. Attachment 1 is a copy of this list. The Air Quality Division hopes that this list will help the hospital permit applicants to better understand what information is necessary, assist the hospitals in submitting complete air quality permit applications, and expedite the review and approval of these types of permit applications. Attachment 2 is an example of the appalication form. Application forms may be obtained by contacting the Air Quality Division.

HOW MANY PERMIT TO INSTALL APPLICATIONS ARE PENDING FOR NEW HOSPITAL INCINERATORS?

Answer:

Ten permit to install applications for new hospital incinerators have been submitted and are currently being evaluated by the Michigan Air Pollution Control Commission's staff. Table 4 contains a listing of these applications, along with information regarding the date the application was received, the permit application number, the permit applicant, the location of the proposed hospital incinerator, the incinerator manufacturer, and the capacity of the proposed incinerator.

WHAT HAS BEEN THE CHRONOLOGY OF EVENTS REGARDING THE AIR QUALITY DIVISION'S EVALUATION OF HOSPITAL INCINERATORS DURING THE PAST YEAR?

Answer:

November of 1985 through February of 1986 - The Air Quality Division began receiving information which indicated that emissions of acids, heavy metals and organics from hospital incinerators could pose a significant health risk.

February 26, 1986 - Air Quality Division permitting staff concluded that the data concerning toxic emissions from hospital incinerators were of sufficient concern to warrant a thorough review for the larger hospital incinerator applications which had a design rate of more than 1000 pounds per hour of waste.

April of 1986 through June of 1986 - Additional emission data concerning hospital incinerators was received and reviewed by the Air Quality Division which indicated that all hospital incinerators, including the smaller units, could pose serious health risks to patients in the hospitals and the public who live in the area surrounding the hospitals.

July 1986 - The Air Quality Division began requesting all hospitals which were proposing to install new incinerators to quantify their emissions of known toxic pollutants and to address the feasibility of adding additional air pollution control equipment.

July 1986 through November 1986 - The Air Quality Division had many telephone contacts and meetings with various people involved in the permitting of hospital incinerators. The Air Quality Division continued to perform a more detailed analysis to better quantify the emissions from hospital incinerators and their impacts on the air intake units for hospitals and the area immediately surrounding the hospitals.

November, 1986 - The Air Quality Division performed a statistical analysis of the available emission data to determine the 95 percentile emission rates. This information is used to calculate the in-stack concentrations and through dispersion modeling, the ground level concentrations.

November 1986 through January 1987 - Dispersion modeling was completed to determine the necessary stack heights for those units whose applications were complete.

January 6, 1987 - The Air Quality Division's evaluation of Permit to Install Number 19-86I, for the new incinerator at Allegan General Hospital was completed. The hospital had originally proposed a 35 foot stack, but agreed to install a 68 foot stack in order to assure that the operation of the incinerator will not cause any adverse effects on human health or the environment.

TABLE 1

HOSPITAL INCINERATOR EMISSION RATES

BASED ON AVAILABLE TEST DATA

Pollutant		Based on statistical analysis of test data 95 Percentile
Cadmium[2]		0.4917 mg/m³
Carbon Monoxide[3,4,6]		1243.90 ppmv
Chromium[2]		0.2871 mg/m³
Dioxins[2]		353 ng/m³
Furans[2]		784 ng/m³
Hydrogen Chloride[2,3,4,5,7]		1399 ppmv
Nitrogen Oxides[3]		229 ppmv
PCB[2]	8.98 ug/m³	
Mercury[2]	0.003 mg/m³	
Sulfur Dioxide[1]	86 ppmv	
Arsenic[1]	12 ug/m³	

(All values at 12% CO_2, dry)

Sources

[1] Jackson County Staff Report
[2] Royal Jubilee Hospital test data
[3] Alta Bates Hospital test data
[4] Illinois test data
[5] Almega Corporation test data from Erlanger Medical Center
[6] Oak Forest Hospital test data
[7] Queen of the Valley Hospital test data

Prepared by Lynn Fiedler

TABLE 2

ALLEGAN GENERAL HOSPITAL GROUND LEVEL AND AIR INTAKE IMPACTS

BASED ON 95 PERCENTILE EMISSION FACTORS

Original Stack Height = 35 Feet

		Concentration (ug/m^3)			Fraction of Accepted Amb.	
Pollutant	**#/Hr.**	**Ground Level**	**Air Intake**	**Accepted Amb.**	**Ground Level**	**Air Intake**
HCL	3.55	73.3	3380	70	1.1	48.3
Cadmium	8.25x10E-4	7.24x10E-4	1.18x10E-2	5.60x10E-4	1.3	21.1
Chromium	4.82x10E-4	4.23x10E-4	6.89x10E-3	8.30x10E-5	5.1	83.0
Arsenic	2.00x10E-5	1.76x10E-5	2.86x10E-4	2.30x10E-4	0.1	1.2
Mercury	5.00x10E-5	7.15x10E-5	1.44x10E-3	0.5	1.4x10E-4	2.9x10E-3
PCBs	1.50x10E-5	1.32x10E-5	2.14x10E-4	1 x 10E-3	1.3x10E-2	0.2
Dioxins & Furans	1.90x10E-6	1.27x10E-8*	2.07x10E-7*	2.30x10E-8*	0.6	9

Necessary Stack Height = 68 Feet

		Concentration (ug/m^3)			Fraction of Accepted Amb.	
Pollutant	**#/Hr.**	**Ground Level**	**Air Intake**	**Accepted Amb.**	**Ground Level**	**Air Intake**
HCL	3.55	17.6	61.7	70	0.3	0.9
Cadmium	8.25x10E-4	8.84x10E-5	1.28x10E-4	5.60x10E-4	0.2	0.2
Chromium	4.82x10E-4	5.16x10E-5	7.47x10E-5	8.30x10E-5	0.6	0.9
Arsenic	2.00x10E-5	2.14x10E-6	3.10x10E-6	2.30x10E-4	1.0x10E-2	1 x10E-2
Mercury	5.00x10E-5	1.38x10E-5	5.21x10E-5	0.5	2.8x10E-5	1.0x10E-4
PCBs	1.50x10E-5	1.61x10E-6	2.33x10E-6	1 x 10E-3	1.6x10E-3	2.3x10E-3
Dioxins & Furans	1.90x10E-6	1.55x10E-9*	1.49x10E-8*	2.30x10E-8*	0.1	6.5x10E-1

*Based on 2, 3, 7, 8 - TCDD Toxic Equivalency

TABLE 3

HOSPITAL STACK AND BUILDING HEIGHTS

Hospital	Building Height(ft)	Initially Proposed Stack Height (ft)	Stack Height Necessary
A	28	35	68
B	135	138	Modeling not completed
C	70	50	Modeling not completed
D	212.2	227.5	Modeling not completed
E	95	122.5	157.5
G	74	94	Modeling not completed
I	12	25	50

TABLE 4

PENDING PERMIT TO INSTALL APPLICATIONS FOR HOSPITAL INCINERATORS

Application Received	Application Number	Facility	Location	Inc. Mfr.	Inc. Capacity (PPH)
12/4/85	26-85I	University of Michigan	Ann Arbor	Basic Env'l. Eng.	1,500
1/29/86	2-86I	St. Mary's Hospital	Saginaw	Consumat	1,100
5/23/86	15-86I	On-Site Technologies	No Site Selected	Shenandoah	120
5/30/86	16-86I	Beyer Hospital	Ypsilanti	JAR Incin. Serv.	300
7/11/86	20-86I	Butterworth Hospital	Grand Rapids	Consumat	175
8/25/86	26-86I	William Beaumont Hosp.	Royal Oak	Morse Bolger	500
8/22/86	27-86I	SAC Wurtsmith Air Force Base	Iosco County	Hesston	Unknown
10/22/86	30-86I	Pawating Hospital Assn.	Niles	Atlas	340
11/6/86	32-86I	Ingham Medical Center	Lansing	Consumat	290
11/6/86	33-86I	Community Health Center of Branch County	Coldwater	Consumat	85

ATTACHMENT 1

SUPPLEMENTAL INFORMATION REQUIRED FOR A COMPLETE AP-2 PERMIT APPLICATION FOR THE INSTALLATION OF HOSPITAL WASTE INCINERATORS

1. A plot plan of the site with scale, indicating building locations and dimensions [length, width, and height(s)]; building air intake vent locations and height(s); and stack location(s), exit dimension(s), and height(s).

2. A detailed written description of the incinerator covered by this permit application including a copy of the manufacturer's literature. Indicate the length, width, and height; or the length and diameter (in feet) of each chamber.

3. A detailed description of the amount, type, and source of each hospital waste stream which will be burned. Include the higher heating value and the net heating value (in BTUs per pound) and the ultimate analysis for the hospital waste. All assumptions, calculations, and other documentation used to derive these values must also be provided.

4. The maximum and normal operating schedule for the incinerator, in hours per day and days per year.

5. The temperature profile and the retention time at 1800°F for the normal and "worst case" waste conditions. All assumptions, calculations, and other documentation used to derive these values must also be provided.

6. A description of the temperature monitoring and recording system to ensure that 1800°F and a gas retention time equal or over one second are achieved and maintained.

7. Describe in detail the procedures and the methods used to insure that 1800°F is achieved and maintained during incinerator startup and shutdown and during periods when high moisture/low BTU waste is charged into the incinerator. Please include the type and maximum fuel firing rate of the auxiliary fuel. If fuel oil is to be used, include the fuel type and maximum sulfur content. All assumptions, calculations, and other documentation used to derive these values must also be provided.

8. The volumetric flow rate in actual cubic feet per minute and in dry standard cubic feet per minute, at 70°F, corrected to 12% CO_2, and the expected temperature (in °F) of the exhaust gases for each stack exit point(s). Please provide the percentages of carbon dioxide, moisture, and excess air in the exhaust gases when operating at maximum design conditions. All assumptions, calculations, and other documentation used to derive these values must be provided.

9. A description of the combustion controls (such as flame out sensors; air and fuel controls; and chamber temperature monitors). Indicate if you are planning to install carbon monoxide (CO), oxygen (O_2), carbon dioxide (CO_2), opacity, or other pollutant monitors, and if so, please describe how these monitors are tied into the combustion controls. Please provide the

combustion controls or monitors set points for normal operation and for triggering an alarm, the method of alerting the controller of abnormal operations (lights, alarms, etc.), and the exact location in the system to be monitored. Also please describe the combustion control strategy and how all the air supply fans and combustion controls are integrated.

10. A discussion of the physical and economic (the installation and operational costs) feasibility of installing and operating an acid gas scrubbing system and a high efficiency particulate collector on the incinerator. All assumptions, calculations, and other documentation used to derive these parameters must also be provided.

11. A complete description of the emission control equipment for the incinerator including expected efficiency and guaranteed efficiency in percent for each pollutant controlled. All assumptions, calculations, and other documentation used to derive these values must also be provided.

12. A statement indicating whether a bypass of the emission control equipment and main stack is provided. If there is a bypass, include a complete description of the circumstances that would cause a bypass and how long the incinerator would operate in the bypass mode.

13. The location and specifications of the stack sampling ports. A description of any rain protection devices on the stack(s).

14. A description of the ash handling system including amount of ash collected (in pounds per hour or pounds per batch), method to prevent air emissions, method of transport, and disposal location.

15. A complete description of the preventative maintenance and malfunction abatement program(s) for the incinerator, emission control system(s), and monitoring system(s).

*16. The maximum uncontrolled and controlled emission rates (in pounds per hour and tons per year) of each of the following pollutants. All assumptions, calculations, stack tests, and other documentation used to derive these values must also be provided. Please keep in mind that the maximum emission rates may become legally binding permit conditions. The emission rate estimates should provide a reasonable margin of safety to ensure that your incinerator can continuously operate at or below these levels.

a. Particulate
b. Sulfur Dioxide
c. Nitrogen Oxides, expressed as NO_2
d. Carbon Monoxide
e. Polychlorinated Biphenyls (PCBs)
f. Mercury
g. Arsenic
h. Cadmium

i. Chromium
j. Total polychlorinated dibenzo-p-dioxins (PCDDs), Tetra through Octa isomers
k. Total polychlorinated dibenzofurans (PCDFs), Tetra through Octa isomers
l. Hydrogen Chloride

*17. For each of the above pollutants, a demonstration that these proposed emissions will not cause injurious effects to human health and safety. (The Michigan Air Pollution Control Commission Rule 901 prohibits the emission of any air contaminant that may cause injurious effects to human health or safety.) Your demonstration must include the effects on people outside the hospital due to ground-level impacts, and the effects on patients and other people inside the hospital (and any other nearby buildings) due to impacts at air intakes, windows, and other building openings.

*Upon request, the Air Quality Division (AQD), DNR, can supply statistical emission rate data (Item 16) which has been compiled from the available test data, and the AQD can evaluate the acceptability and safety of the emissions (Item 17) using the technical methods which have been developed and utilized by the Michigan Air Pollution Control Commission. The supplier of the incinerator should be able to submit the information requested in items 1-15 with some assistance from the hospital administrators on items 1, 3, and 4.

Air Quality Division
Permit Section
January 9, 1987

ATTACHMENT 2

AIR QUALITY DIVISION
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
P.O. BOX 30028, LANSING, MICHIGAN 48909

APPLICATION NO.

APPLICATION TO THE AIR POLLUTION CONTROL COMMISSION

for authority to construct, install, or alter and for permit to operate an incinerator

1. PERMIT TO BE ISSUED TO: *(Business License Name of Corporation, Partnership, Individual Owner, Government Agency)*

2. MAILING ADDRESS: *(Number, Street, City or Village, Zip Code)*

3. EQUIPMENT OR PROCESS LOCATION: *(Number, Street, City or Village, Township, Zip Code)*

4. TYPE OF ORGANIZATION: ☐ Corporation ☐ Partnership ☐ Individual Owner ☐ Governmental Agency

5. GENERAL NATURE OF BUSINESS:

6. ☐ New ☐ Modification

7. Make of Incinerator | Model | Class | Rated Capacity (lb/hr)

8. Type of Waste | BTU/lb. as Fired | Daily Amount (lbs.) ☐ Estimated ☐ Actual

PRIMARY COMBUSTION CHAMBER

9. Volume (cu. ft.) | Effective Grate & Hearth Area (sq. ft.) | % Excess Air | Adjustable ☐ YES ☐ NO

Total Heat Release (BTU/hr/cu. ft.) | % Air Applied as Overfire Air | % as Underfire

SECONDARY COMBUSTION CHAMBER (Main Section)

10. Volume (cu. ft.) | Gas Velocity (ft/sec) Maximum | Temp. of Maximum | Estimated Hold Time of Gas in Chamber (sec)

BURNERS

11. Primary: ☐ Power ☐ Atmospheric Capacity (BTU/hr) # | Secondary: ☐ Power ☐ Atmospheric Capacity (BTU/hr) #

DAMPERS

12. Breeching: ☐ Barometric ☐ Positive (slide) | Stack: ☐ Barometric ☐ Positive (slide)

AIR POLLUTION CONTROL EQUIPMENT

13. ☐ Spark Arrester ☐ Settling Chamber ☐ Other

Type | Manufacturer | Capacity (cfm) | Efficiency

14. Stack | Material(s) of Construction | Inside Diameter (ft)

Height Above Grade (ft) | Height Above Roof of Bldg. Where Installed (ft) | Distance to Nearest Obstruction (ft) | Fan Used ☐ YES ☐ NO Capacity (cfm) S.P.

15. ☐ Outdoor installation ☐ Indoor installation If indoor, describe method of supplying combustion air on additional sheet.

16. Briefly describe general nature of the area in which unit is located on additional sheet.

17. Modification — Describe modifications in detail on additional sheet.

18. Manufacturer's estimate of emission loading (lbs. per 1,000 lbs. gas) | Is test data available? ☐ YES ☐ NO

19. PRESENT STATUS OF EQUIPMENT: *(Check and complete applicable items)*

	Estimated Starting Date	Estimated Completion Date
( ) Construction or installation not started	______	______
( ) Construction or installation partly completed	______	______
( ) Construction completed	______	______
( ) Equipment is to be altered	______	______
( ) Equipment is partly altered	______	______
( ) Equipment has been altered	______	______
( ) Change of location and/or ownership	______	______

20. NAME OF PRIOR OWNER AS IN (1) ABOVE, AND PRIOR AIR POLLUTION CONTROL PERMIT NUMBER, IF ANY:

(Name) *(Permit Number)*

21. TYPE OR PRINT NAME AND TITLE OF OWNER OR AUTHORIZED MEMBER OF FIRM

(Name) ______ *(Title)* ______

(Signature) ______ *(Date)* ______ *(Phone No.)* ______

22. DISPOSITION OF APPLICATION:

Permit to install approved and issued on ______ Signature ______

Permit to operate approved and issued on ______ Signature ______

FORM AP-2 2M 10/75 (INSTRUCTIONS FOR COMPLETING THIS FORM ARE ON REVERSE SIDE)

APPLICATION INSTRUCTIONS

Submit this form in triplicate; complete application requires specifications and drawings in duplicate. This application must be signed by the owner or authorized member of firm. Additional comments on use of the application are noted below.

1. Name of owner of incinerator. If leased, state name of lessee.
2. Address at which the incinerator is being installed.
7. Name of the manufacturer of the incinerator and the manufacturer's model number, initial or name. State class of incinerator and rated capacity of incinerator in pounds of material burned per hour.
8. State type of waste to be burned in the incinerator and the BTU per pound value of the waste to be burned. State daily amount of waste to be burned and check whether this is estimated or the actual amount.
12. Check types of air pollution control equipment to be installed in the incinerator. If "other" is checked, insert the type (inertial, wet scrubber), manufacturer and efficiency of the equipment.
16. Briefly describe the area surrounding the plant including such factors as the topography of the area, distance to the property line, zoning of the area, etc.
17. If the application is for modification of an existing unit, describe in detail the proposed modification to be made.

GUIDE TO INCINERATOR CLASSIFICATION SYSTEM

CLASS OF INCINERATOR	DESCRIPTION OF CLASS	TYPE OF WASTE BURNED	DESCRIPTION OF TYPE OF WASTE	% INERT WASTE	% MOISTURE OF WASTE	HEATING VALUE WASTE BTU/LB	CAPACITY BURNING RATE OF WASTE IN LBS/HR
I	Portable, packaged, completely assembled direct feed	0	Trash 100%	0-5	0-10	8500	0-24
		1	Rubbish 100% Up to 20% garbage	0-10	0-25	5500-8500	
		2	Rubbish 50% and garbage 50%	0-10	30-60	1900-4800	
IA	Portable, packaged, or job assembled direct fired	0	Trash 100%	0-5	0-10	8500	25-99
		1	Rubbish 100% Up to 20% garbage	0-10	0-25	5500-8500	
		2	Rubbish 50% and garbage 50%	0-10	30-60	1900-4800	
		3	Garbage 100% Up to 35% rubbish	5-10	60-85	500-3000	25-74
II	Flue fed type incinerators (Single chamber)	0	Trash 100%	0-5	0-10	8500	All Sizes
		1	Rubbish 100% Up to 20% garbage	0-10	0-25	5500-8500	
		2	Rubbish 50% and garbage 50%	0-10	30-60	1900-4800	
IIA	Flue fed type incinerators (Multiple chamber)	0	Trash 100%	0-5	0-10	8500	All Sizes
		1	Rubbish 100% Up to 20% garbage	0-10	0-25	5500-8500	
		2	Rubbish 50% and garbage 50%	0-10	30-60	1900-4800	
III	Direct fired incinerators	0	Trash 100%	0-5	0-10	8500	100 or More
		1	Rubbish 50% Up to 20% garbage	0-10	0-25	5500-8500	
		2	Rubbish 50% and garbage 50%	0-10	30-60	1900-4800	
IV	Direct fired	3	Garbage 100% Up to 35% rubbish	5-10	60-85	500-3000	75 or More
V	Municipal incinerators	0, 1, 2 & 3	Variable mixture	Variable	Variable	Variable	Municipal usage
VI	Crematory and pathological incinerators	4	100% animal and human tissue	2-5	80-90	600-1700	All Sizes
VII	Special design for specific by-product wastes	5	Gaseous, liquid or semi-liquid wastes	Variable	Variable	Variable	All Sizes
		6	Semi-solid and solid wastes				

Yellow copy to be retained by applicant

CHATTANOOGA - HAMILTON COUNTY PERMITTING EXPERIENCE

J. Wayne Cropp
Director
Chattanooga - Hamilton County
Air Pollution Bureau

Presented at:

HOSPITAL INFECTIOUS WASTE/INCINERATION AND HOSPITAL STERILIZATION WORKSHOP

Golden Gateway Holiday Inn
San Francisco, CA
May 10-12, 1988

I. Definitions

A. Pathological waste - Chattanooga definition (adopted in 1973)

All or parts of organs, bones, muscles, other tissues and organic wastes of human or animal origin, laboratory cultures and infective dressings and other similar material.

B. Use of term "pathological" is a misnomer because of the "breath" of items covered in local ordinance under what is normally a more limited term.

C. Possible designations of "infectious" waste

1. pathological wastes - tissues, organs, body fluids
2. human blood and blood products - serum, plasma
3. contaminated animal carcasses, body parts, and bedding
4. cultures and stocks of infectious agents and associated biologicals - culture dishes
5. contaminated sharps - hypodermic needles, syringes, scalpel blades
6. isolation wastes
7. miscellaneous contaminated wastes - soiled dressings, sponges, underpads, surgical gloves, slides, specimen containers, dialysis unit wastes

D. Types of solid waste designated as infectious

Source/Type of Solid Waste	CDC	EPA	JCAH	CITY
Pathological	yes	yes	yes	yes
Blood & blood products	yes	yes	n/a	yes
Animal waste, contam.	n/a	yes	n/a	yes
Microbiological	yes	yes	yes	yes
Sharps	yes	yes	no	yes
Isolation	HP	yes	yes	yes
Other waste	no	HP	no	yes

HP = hospital policy
CDC = Center for Disease Control
JCAH = Joint Commission on Accreditation of Hospitals

II. Chattanooga Permit System

A. Have utilized incinerator Institute of America solid waste classification scheme for designation of waste classification

1. pros
    a. extensively used in USA
    b. used by equipment manufacturers

2. cons
    a. does not address plastics content or hazardous components

III. Chattanooga Standards

A. Regulatory emission limit - particulate

1. 0.1 lbs. per 100 lbs. charged
    a. for entire burn cycle

2. 0.20 grains @ 12% CO_2
    a. excluding fuel used
    b. more stringent than simple correction for CO_2.

B. Design criteria

1. multiple chamber required

2. primary chamber - 800°F

3. secondary chamber - 1500°F

4. other designs may be considered, other than above three criteria, if mass standard can be achieved

5. no visible emissions allowed from any "pathological" unit

C. Licensing requirement

1. required for person in responsible charge

2. $10.00 fee for administering standardized test

3. may be revoked for
    a. willful violation
    b. violation through incompetent operation

IV. Erlanger Case Study

A. Background

1. public health care facility
    - a. 754 beds
    - b. operations - regional tertiary care center

2. operated one Consumat pathological waste incinerator
    - a. 85 pounds per hour

B. Permit application

1. permit applied for in January 1982

2. two continuous feed, Basic (John Basic design) Model 1250 heat recovery incinerators

3. Type 0 and 1 waste only - Incinerator Institute of America designation (did not include pathological)

C. Special permit conditions imposed (BACT)

1. tight operations requirements but no add-on controls required

2. 0.08 gr/dscf

3. 1625°F (secondary chamber)

D. Units constructed and tested

1. constructed - 1983

2. tested for TSP - February 1984

E. Annual inspection - 1986

1. all facilities inspected annually.

2. March 1986 - temperature requirements violated on numerous occasions over past year

3. NOV issued (April 1986)

4. modifications made to system by July 1, 1986
    - a. grate system replaced
    - b. increased burner capacity

5. resolved enforcement action - no penalty

F. New York City test burn

1. September 1986
    a. "trial burn" of hospital waste conducted
    b. came from 11 hospitals, over 14,000 lbs.

2. "for-profit" proposal under consideration

3. November 1986
    a. employee reported to county and news media
    b. concerned about AIDS due to injury during the trial burn

G. Enforcement investigation

1. had burned out-of-state waste on September 11-12, 1986

2. had been burning hospital's own "red bag waste" after July 86 modifications
    a. permit violation
    b. only Type 0 and 1 waste allowed

3. had violated temperature requirements on 42 occasions between July 1986 and November 1986
    a. documented in company's written logs

4. had violated temperature requirements during "trial burn"

5. enforcement action initiated

H. Consent decree negotiations

1. control equipment
    a. dry lime acid scrubber, baghouse

2. increased secondary chamber temperature requirement to 1800°F

3. specified residence time - 1 second (secondary)

4. continuous temperature recorder required

5. assessed penalty - $72,500

6. are not burning waste for others

V. Compliance Program at Area Hospitals

A. Disposal and operational practices

1. penalized another hospital for burning "pathological" waste in general refuse unit - $15,000
    a. no mass, temperature or opacity violations recorded

2. initiated tests at all units (pathological and general refuse)
    a. had not previously required tests of small units

3. compliance status poor, at best
    a. equipment not functioning at manufacturers representations

4. dioxin tests not required due to lack of standard - associated costs

5. tested for: particulates, hydrogen chloride, chlorine, temperatures (primary & secondary), residence time, and opacity

B. Testing requirement reaction

1. one hospital incinerator shutdown, 100% Opacity (continuous feed)

2. seven food stores shutdown incinerator (general incinerator regs.)

3. one storage company shutdown incinerator (general incinerator regs.)

C. Testing program reviewed

1. local requirements

2. proposed Tennessee regulations considered
    a. HCl, residence time

3. spore tests at two hospitals

VI. Proposed State Regulations

A. Regulatory emissions limits

1. 0.1 gr/dscf for particulate - corrected to 12% CO_2
2. HCl - air quality impact not to exceed 70.0 mg/m^3 on a 24-hour basis
3. opacity not to exceed 10% (6-minute average) except not to exceed 20% during one 6-minute period in any hour

B. Design criteria

1. multi-chamber
2. solid hearth (or equally effective)
3. secondary chamber - 1600°F
4. residence time
    - a. new units must meet 1.0 second

C. Burning of antineoplastic drugs

1. new or existing
    - a. 1.5 seconds residence time
    - b. 1800°F secondary temperature

D. Charging systems

1. batch loading systems must have a lockout
2. others must have an automatic loading device with an interlock

VII. Pathological Incinerator Testing Summary

Hospital	A	B	C	D		City Regulation
Type Results	Batch Charge	Batch Charge	Batch Charge	Continuous Charge		
				Unit 1	Unit 2	
1) Particulate						
total lbs. per 180 min.	0.13	0.07	0.19*	n/a	n/a	0.1 lbs/100 lbs charge
average lbs per hour	n/a	n/a	n/a	0.25	0.20	0.1 lbs/100 lbs charge
2) Rule 7.4 Allowable	0.28	0.32	0.51	1.25	1.25	
3) Avg. gr/dscf						
@ 12% CO_2 - Fuel	0.09	0.14	0.49	--	--	n/a
@ 12% CO_2	0.06	0.03	0.06	0.02	0.02	**
4) HCl						
lbs. per 180 min.	1.42	2.12	1.28	n/a	n/a	None
average lbs. per hour	n/a	n/a	n/a	12.23	8.56	None
5) Cl_2						
lbs. per 180 min.	0.01	0.02	0.05	n/a	n/a	None
average lbs. per hour	n/a	n/a	n/a	<0.02	<0.02	None
6) Primary Temperature °F	450-1300	350-680	330-800	1115-1636	1351-1781	800°F
7) Secondary Temperature °F	1650-1800	1800-1900	1650-1860	1858-2089	1798-2143	1500°F (A, B, C) 1800°F (D)
8) Retention Time Seconds	0.97	0.19	1.03	2.10	2.10	None
9) Spore Test	ND	No trace	Complete Destruction	n/a	n/a	None
10) VE %	0	0	0	0	0	No VE

* lbs. per 240 min.

** 0.10 gr/dscf (state)
0.08 gr/dscf ("D" Consent Decree)

VIII. Lessons Learned

A. Do not accept manufacturers' representations without further inquiry.

B. Require individual tests on all units.

C. Information about pathogen survival and low level nuclear waste has been hard to come by.

D. Primary issue for us became plastics content and resulting emissions.

   1. dioxins and furans

E. Medical solid waste practices are often poor.

F. Do not allow solid waste problem to become an air pollution problem.

   1. require tight controls - up front

MARYLAND'S PERMITTING EXPERIENCE

Tad Aburn
Maryland Department of
Health and Mental Hygeine
Air Management Division

Presented at:

HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP

Hotel Belvedere
Baltimore, MD
May 24-26, 1988

DEFINITION OF INFECTIOUS WASTE

"Infectious waste' means any material or item of a disposable nature known or suspected to be contaminated with organisms capable of producing disease in humans, biological and laboratory waste, pathological waste, and sharps such as needles.

Also includes animals and animal contact items such as bedding contaminated with organisms that may be pathogenic to humans.

MARYLAND'S POLICY REGARDING THE DISPOSAL OF INFECTIOUS WASTE

1. Landfilling and municipal incinerators.
2. Hospital waste versus infectious waste.
3. On-site versus off-site incineration.
4. Autoclave and other alternative disposal methods.

CURRENT STATUS OF MARYLAND'S PROGRAM

1. Currently have 116 on-site incinerators.
2. One commercially available incinerator has special service for physicians offices and other small generators.
3. One regionalized 100 ton per day unit at proposal stage.
4. Acid gas scrubbers.
5. Existing Guidelines - proposed regulations.

MARYLAND'S PROPOSED AIR TOXICS REGULATION

1. Applies to infectious waste incinerators.
2. Three Basic Requirements.
    - Estimate emissions.
    - Best available control technology for toxics (T-BACT) for new sources.

- Demonstrate that emissions "Do not unreasonable endanger human health" by use of:
  - (a) Conservative screening analysis
  - (b) More sophisticated analysis
  - (c) "Risk Management" for Carcinogens

PERMITTING EXPERIENCES

1. Analyze commercial hospital waste incinerator with a 1000 lb/hr unit.
2. Applying for a second 1000 lb/hr incinerator.
3. Industrialized area, 30 foot stacks, and no proposed acid gas scrubber.

SCREENING ANALYSIS - 3 STEPS

1. Estimate emissions.
   - EPA emission factors - screen with higher values
2. Estimate highest off-property concentrations.
   - Conservative screening dispersion model (AMA TM 86-02)
   - ISC-LT and ISC-ST for more detailed dispersion modeling
3. Compare off-property concentrations to screening levels for each substance discharged.

SCREENING ANALYSIS RESULTS

Substances Considered	Off-Property Concentration (ug/m^3)		Screening Level (ug/m^3)	
Hydrogen Chloride	6100	(1-hr)	70	(1-hr)
Dioxins and Furans	620×10^{-7}	(annual)	3×10^{-7}	(annual)
Cadmium	0.014	(annual)	0.006	(annual)
Chromium	0.0014	(annual)	0.0008	(annual)
Arsenic	0.00062	(annual)	0.002	(annual)

- HCL, Dioxins, Cadmium and Chromium did not screen out.
- Other substances and short-term screening levels for listed substances are not included as they all "screened out."

MORE DETAILED ANALYSIS

- "Special screening level" for HCL - 150 ug/m^3 (3 min. average)
- Complex modeling
- Average emissions for annual concentrations
- Highest emission rate for HCL (3 min. average)
- Adjust stack height

RESULTS OF MORE DETAILED ANALYSIS

(80 Ft. Stack To Avoid Downwash)

Substances Considered	Off-Property Concentration (ug/m^3)		Screening Level (ug/m^3)	
Hydrogen Chloride	500	(3 min.)	150	(3 min.)
Dioxins and Furans	2×10^{-7}	(annual)	3×10^{-7}	(annual)
Cadmium	0.001	(annual)	0.006	(annual)
Chromium	0.0001	(annual)	0.0008	(annual)
Arsenic	Screened out		Screened out	

- Even with a 200 foot stack, HCL emissions resulted in a level almost double its special screening level (250 ug/m^3 compared to 150 ug/m^3 - both 3 min. averages).

ROUGH REVIEW OF EPA MODEL UNIT

1. Characteristics of larger model plant.
    - No acid gas controls
    - 1000 lb/hr
    - 78 foot stack
    - 450 to 1144°F exit velocity
2. Review used EPA emission factors, EPA "Reference Air Concentration" (RAC) for HCL and our modeling.
3. Results
    - EPA's model unit caused concentrations all most twice as high as the proposed RAC.

4. Conclusions

   - Many larger infectious waste incinerators across the country may have HCL problems.

REMAINING ISSUES

1. Acid gas controls.
2. Acceptable HCL levels in the ambient air.
3. HCL emission rates.
4. Continuous emission monitoring.
5. National policy on acid gas controls for infectious waste incinerators.

BRIEF SUMMARY OF DRAFT AIR TOXICS REGULATIONS

February 1988

This summary describes the major provisions of Maryland's draft air toxics regulations. It discusses the pollutants and sources covered as well as the three major requirements.

Toxic air pollutants include a large number of carcinogens and non-carcinogens for which no national or state ambient air quality standards have been established. The draft regulations call carcinogens "Class I TAPs" and other toxics "Class II TAPs."

The number of substances regulated as toxic air pollutants will be larger for new than for existing sources. For existing sources, the draft regulations contain a specific list of pollutants. For new sources, there is a somewhat longer list of Class I TAPs (carcinogens) and an open-ended definition of Class II TAPs that is based on the term "health hazard" in the State Right-to-Know laws.

The sources governed by the regulations are identified in the sections concerning applicability. In general, the regulations will apply to any source required to get an air quality permit. Certain small sources are exempt, and there are specific exemptions for fuel burning equipment, char broilers, and gasoline stations.

There are three major requirements:

1. The requirement to quantify emissions of toxic air pollutants.
2. A requirement that most new sources use the best available control technology for toxics (T-BACT).
3. The requirement that a source not unreasonably endanger human health.

The requirement to quantify TAP emissions will require new sources to quantify any TAP discharged. For existing sources, however, the requirement is limited to specifically listed TAPs. The regulations specify deadlines for existing sources to submit emissions information.

The T-BACT requirement is very flexible and allows the Department to consider both the toxicity of substances discharged and the costs of controlling emissions on a case-by-case basis.

The third requirement is also called the "ambient impact" requirement, because in order to demonstrate compliance, a source must show that it will not increase concentrations of TAPs in the ambient air by more than certain levels. Existing sources must comply with the ambient impact requirement by 1990 or 1992 depending on which TAPs are discharged.

The ambient impact requirement is the most complex part of the regulations, because there are several options a source may use to demonstrate that its emissions do not unreasonably endanger human health. The primary option is to demonstrate that the source will not increase ambient concentrations by more than applicable "Screening Levels." The second option is a "Second Tier Analysis." There is a third option for Class I sources, involving a "Special Permit."

Screening Levels are established for both carcinogens and for other toxic effects. Screening Levels for carcinogenic effects are called "Risk Based Screening Levels" since they are developed using risk assessment. The Risk Based Screening Level represents a maximum individual lifetime cancer risk of one in 100,000. Screening Levels for other toxic effects may be based on Threshold Limit Values (TLV-Based Screening Levels). If no TLV is available, the regulations contain procedures for developing Screening Levels based on toxicity data establishing thresholds for various health effects (Threshold-Based Screening Levels). Since these Screening Levels are developed using methods that may not be appropriate for every substance, the regulations also provide that the Department may adopt Special Screening Levels to more adequately reflect toxic effects other than cancer.

Screening Levels are intended to be conservative so that public health will be protected even though only one source is evaluated at a time. However, a mechanism is provided in the "Second Tier Analysis" to consider multiple sources of a TAP and to develop a less conservative though still protective Acceptable Ambient Level to replace a Screening Level for noncarcinogenic effects.

The Second Tier option also provides for the development of "Insignificant Risk Concentrations" in cases where new data indicates that a Risk-Based Screening Level should be revised. This option will involve a re-analysis of the dose response data for a carcinogen.

Finally, the Special Permit option for Class I TAPs involves a reassessment of the exposure to a carcinogen and the acceptable risk level. Screening Level analysis assumes that a person will be continuously exposed for 70 years to the highest TAP concentration predicted to occur off the source's property. Since this assumption is very conservative, the Special Permit option provides for the opportunity to use more realistic exposure assumptions. In addition, if necessary, the Special Permit provides the opportunity to accept risks that may exceed one in 100,000.

SESSION V: AGENCY PERMITTING EXPERIENCES

SUMMARY OF DISCUSSION (SAN FRANCISCO)

Q: What has been the permitting experience of burning infectious waste in a municipal waste incinerator?

A: (Unidentified speaker) New York is inclined to support the burning of infectious waste in municipal burners because the burning conditions in the new facilities are at least as good as what we are proposing for hospital waste incinerators. However, there is a problem of the grates being too large (body parts can fall through). The disadvantage is in operation — there is not enough control. Pathological and infectious wastes will get mixed up with municipal waste if the waste is picked up from commercial establishments, be it doctors, dentists, or clinics.

(Unidentified speaker) Workers are not enthusiastic about touching the infectious material. Agencies have to encourage people in municipal waste incineration to accept these materials, perhaps through separate streams, or by using boxes for infectious waste.

(M. Tierney, WI DNR) Wisconsin encourages each facility to burn its own waste so the regulators would not have to make the distinction of what is or is not infectious waste.

(N. Coleman, OK DOH) Oklahoma allowed one municipal waste incinerator to burn hospital waste. There are special provisions in their permit. The hospital cannot compact the waste prior to sending it to the facility. The municipal waste incinerator must keep it as a separate waste stream, cannot use grappling hooks as a means of loading it into the incinerator, but must use a manual loading system, and have the capacity to disinfect the loading area with live steam. There was initial opposition from the hospitals on not compacting the waste because this meant higher hauling costs, but this has been resolved. A new proposal exists to build a process facility adjacent to the municipal waste incinerator to offer steam sterilization of all waste prior to going into the municipal waste combustor.

(W. Sonntag, NY DEC) Landfills are out; there is no space available. Most communities will have to install some type of incinerator. In that case, the burning conditions will be the same, whether it is a hospital or a municipal facility. The costs should be about the same for both. They may as well combine everything and send it to a municipal incinerator. The costs will probably be higher than they are now, but currently the landfills are inadequate and landfilling costs too low. To upgrade the landfills, the costs will have to increase. The costs will then be more consistent with the cost of incineration.

(N. Seidman, NESCAUM) The issue of small/local vs. large/regional facilities has been raised in some of the NESCAUM states. Larger facilities could be better funded, more able to afford the control equipment, and have better trained operators. However, the problem is siting. It is very difficult to site a municipal waste incinerator on the East Coast. If you try to convince the public that you can burn municipal waste correctly and that you are going to burn pathological waste occasionally, it could set the public against your incinerator, no matter what technical advantages combined burning offers.

Q: Regarding smoke stack heights, are we entering into another "The Solution to Pollution is Dilution?" How does this compare to other "smokestack industries?" Are stack heights varied in other smokestack industries or just for hospital incinerators?

A: (L. Fiedler, MI DNR) Michigan requires BACT. For HCl, we are letting hospitals dilute as a solution. We are getting it away from air intakes and away from hospital patients. In looking at the health impacts, we found that HCl was the factor that was driving the stack height up. Hospitals can meet the requirements for metals, dioxins and furans, but the HCl was the problem.

(G. Aburn, MD DOH) Maryland's policy is that dilution is not the solution. Stacks should be designed for no downwash. Stacks may not be raised for carcinogens because this may increase the total risk by dispersing the emissions and the risk. Raising the stack is a last resort.

(P.K. Leung, Env. Can.) The same discussion is occurring in Canada. BACT eventually implies zero pollution, but until then dilution is necessary. Combine the two until the ambient impact is acceptable.

Q: Acid gas control reduces the stack exit temperature, leading to less dispersion of HCl emissions. Without scrubbers and heat recovery you could have high temperature, high plume rise, and better dispersion. Is there a substantial reduction in ambient HCl concentrations with a scrubber?

A: (L. Fiedler, MI DNR) Perhaps agencies should consider proposed stack heights with and without control equipment, and do dispersion modeling to make sure the impacts are acceptable.

Q: Do agencies use toxic equivalency factors?

A: (G. Aburn, MD DOH) Maryland does not, but instead tries to show that dioxin and furan emissions are acceptable using conservative assumptions. Maryland took the homologue group and treated the whole group as though it were as toxic as the 2,3,7,8 isomer of that group.

(Unidentified speaker) In California, CARB used the factors that were developed by the California Department of Health Services.

(G. Yee, CARB) At the International Los Vegas meeting on dioxin, there appeared to be wide discrepancies among the different scenarios of the toxic equivalent units from the international level. A Research Committee was formed to examine the problem and come up with a consistent scenario.

Q: Wisconsin and Minnesota are considering the impacts of bioaccumulation of toxics in the environment. Are any other states working on bioaccumulation of dioxins, furans, cadmium, or other pollutants?

A: (G. Aburn, MD DOH) New York has materials which show that actual exposures to dioxins (due to emissions into the atmosphere) are higher from non-inhalation routes, than they are from inhalation. The New York contact is Pat Levin.

(N. Seidman, NESCAUM) EPA is working with Minnesota and Vermont on the Vicon municipal waste incinerator and the whole issue of bioaccumulation. The preliminary data should be released in June. Vermont and Detroit, Michigan are completing preoperational monitoring.

(A. Jackson, MN PCA) A health risk assessment in Minnesota was just released. Contact Jeff Stevens at the University of Minnesota for further information on bioaccumulation. The Citizens Board will determine what Minnesota will do with the assessment.

Q: After looking at the routes of exposure, all the models and assumptions, and going through health risk assessments done on municipal waste combustion, how significant are the risks? There seems to be quite a range of risks noted from inhalation. Depending upon what numbers are used, the variation in the overall risk can be quite dramatic.

A: (T. Smith, BAAQMD) The models for non-inhalation pathways are usually borrowed from radiation modeling. The factors and parameters considered are fairly esoteric. Guidelines or assumptions are needed.

(G. Shiroma, CARB) South Coast AQMD's contract study should provide suggested guidelines for these esoteric input parameters. CARB is coordinating with South Coast AQMD in writing guidelines on how to assess risk for resource recovery facilities, municipal waste incinerators, and hospital waste incinerators. This document is to be used by regulators and consultants to guide a potential applicant. The draft is due in August and a workshop is planned for September.

SESSION V: AGENCY PERMITTING EXPERIENCES

SUMMARY OF DISCUSSION (BALTMORE)

Q: What are the general problems with continuous emission monitoring (CEM)?

A: (G. Aburn, MD DOH) The main problems are reliability of data, and maintenance of equipment. CEM for opacity is currently practical, but CEM for HCl needs further development.

Q: What is the Bay Area AQMD position on secondary chamber retention time versus temperature, especially in existing incinerators?

A: (T. Smith, BAAQMD) The manufacturers' concern is consistency of requirements rather than how strict the requirements are. A safety margin is needed, and there is agreement that 2 seconds provides that "cushion."

Q: For existing incinerators the data do not show a need for retrofitting as long as the incinerators are operated properly, e.g. no visible emissions. CARB data should provide useful insight on this.

A: (G. Ferreri, MD DOH) Until recently Maryland had an odor-oriented time/temperature requirement (0.3 seconds at 1400° F), and design of the secondary chamber was based primarily on odor control. A retrofit requirement would in effect mean phasing out existing units.

Q: To control dioxin it must be condensed, e.g. with an acid gas scrubber plus baghouse. However, the biggest problem is operator training.

A: (J. Weyler, Chattanooga-Hamilton Co. APCB) There is a need for a manual for operator training, not in incinerator operation — that is the manufacturer's job — but in the regulations and how to spot problems.

Q: Michigan required 1 second at 1800° F based on experiences with municipal waste incinerators. If temperature decreased, PCDDs increased. Data for PCDDs and PCDFs from hospital incinerators are very limited. Michigan planned to do more testing in the 1600-1800° range since refractory materials are less costly if designed for the lower temperatures. Tests at 2 seconds and 2000° F show that cyclotoxics are destroyed. One must remember the mission — what one is trying to destroy.

Q: Since 1984 Massachusetts has had a standard of 1 second at 1600°. The state discovered recently that its regional offices interpreted this differently, e.g. 1 second absolutely, or 1 second corrected for temperature. What is done elsewhere?

A: (T. Smith, BAAQMD) Bay Area AQMD requires that the minimum temperature specified be maintained for the retention time. The agency inquired of the manufacturers, who stated that the specified temperature should occur "after the last introduction of air."

(R. Telesz, MI DNR) Michigan requires temperature to be maintained on a 1-hour average basis for that 1 second.

Q: In a colder climate, common sense dictates that the incinerator be enclosed in a building. Massachusetts requires as GEP that new facilities be enclosed to allow easier maintenance and testing in all seasons.

A: (R. Telesz, MI DNR) In Michigan as well, the climate requires enclosed incinerators. Also, employee unions favor enclosed facilities.

Q: We can learn from hazardous waste incineration experience. For example, the 25-year old incinerator at Niagara Falls is equipped with a scrubber for HCl but no particulate controls. Burning waste with 62% Cl content, it achieved no detectable PCDD as long as residence time was over 2 seconds at 1000-1200° C. This unit maintained less than 50 ppm CO emissions and 99.95% combustion efficiency. Combustion efficiency is the key, and CO is a good indicator.

Q: What caused the violations reported in Tennessee -- low temperature due to overcharging?

A: (J. Weyler, Chattanooga-Hamilton Co. APCB) One of the problems is what is to be burned. The manufacturer designed the unit for mostly dry waste, but the hospital burned all its wastes so the water content was higher than design conditions.

Q: Hospital waste should be surveyed at intervals for changes in the constituents, e.g. precautions against the AIDS virus have resulted in more vinyl latex gloves and PVC being discarded.

Q: For each panelist: What is considered BACT on new incinerators?

A: (T. Smith, BAAQMD) The District has not made BACT determinations, but the HCl limit is 30 ppm.

(G. Ferreri, MD DOH) If Maryland were to determine BACT, it would probably be an acid gas scrubber followed by a baghouse.

(J. Weyler, Chattanooga-Hamilton Co. APCB) BACT has been established only on the Erlanger incinerator. This facility is designated for a charging rate of up to 1250 lb/hr.

(R. Telesz, MI DNR) Michigan has not done a PSD determination on an incinerator. In performing a BACT-like review of the University of Michigan facility, the agency has called it "state of the art."

Q: For each panelist: What are the stack testing requirements?

A: (T. Smith, BAAQMD) Tests for particulates and HCl are required. No dioxin testing or CEM are required due to the cost.

(G. Ferreri, MD DOH) Maryland has done tests for particulates only, plus tests at one hospital for metals. No tests for PCDDs or PCDFs have been required due to the cost. Extensive testing at one hospital is being used to build a database.

(J. Weyler, Chattanooga-Hamilton Co. APCB) All facilities must test for particulates, HCl, and CO_2, must monitor primary and secondary temperatures and must calculate retention time during the test. These provisions are not yet statutorily required in the County, but State approval is anticipated.

(R. Telesz, MI DNR) Some tests for PCDF and PCDD have been done but Michigan is hesitant to require them because of the cost. HCl and metals are tested at most facilities. Michigan has required future testing (e.g. every 5 years) for HCl because (1) the amount of Cl in the waste stream is increasing, and (2) in the future EPA will lift its ban on PVC in food and packaging materials, and the percentage of PVC in the waste stream is expected to increase.

Q: What are appropriate de minimis levels for (1) requiring testing, and (2) requiring controls?

A: (T. Smith, BAAQMD) Testing should be required to determine compliance. The issue of CEM requirements is complex. It would make sense to have one regional facility with a well supervised CEM operation, but this is unlikely to be realized. CEM is too expensive to require it of every facility. The decision is a philosophical one of balancing needs, rather than application of a defined threshold.

(G. Ferreri, MD DOH) All units are tested, no matter how small, because manufacturers' data submitted to the agency have been inaccurate. The particulate regulation, which specifies 0.1 lb/100 lb charged, is set up so that the facility needs to test in order to comply.

(R. Telesz, MI DNR) The risk limitation is 1 in a million. If the facility cannot meet this, they must relocate the stack or increase its height. If this is not feasible, they must install controls. A similar process applies to HCl through a TLV-related standard.

Q: Is waste analysis required before a stack test?

A: (R. Telesz, MI DNR) Most companies do not analyze waste as part of a compliance test. In Michigan, inspectors observe the waste for PVC.

(J. Weyler, Chattanooga-Hamilton Co. APCB) In the County, an Agency inspector gathers a representative sample of the waste during the test.

Q: How can opacity be monitored if a wet scrubber is in use?

A: (R. Telesz, MI DNR) The usual procedure in Michigan is to wait for the steam to dissipate and then read opacity visually. Opacity testing is required on larger units but not smaller ones because of the cost. Recently Lear-Siegler has been developing a new method which involves sampling the plume, reheating a portion of it, and then reading the opacity.

(J. Weyler, Chattanooga-Hamilton Co. APCB) No hospital incinerators in the County have wet scrubbers. They probably will not be used due to the potential for corrosion by HCl, and their vulnerability to poor operation.

SESSION VI

AGENCY REGULATIONS AND GUIDELINES

HOSPITAL WASTE INCINERATION:
A NEW YORK STATE PERSPECTIVE

Wallace E. Sonntag, P.E.
New York Department of
Environmental Conservation
Division of Air Resources

Presented at:

**HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP**

Golden Gateway Holiday Inn
San Francisco, CA
May 10-12, 1988

REGULATORY BASIS: PARTS 219 and 222

- Adopted 1972 and 1973
- Still in effect
- Apply to smoke, odors, and particulates
- For types 0-4 waste

ISSUES

- Complaints
  - Smoke
  - Odor
- Public Concern
  - All incineration
  - AIDS
- Legislative Concern
- Landfill Problem
  - Closures: 47 of 354 permitted
  - Rejection of red bags
- Commercial Facilities
- Plastics
- Existing regulations are obsolete

INTERIM GUIDANCE -- October, 1986

- To identify good engineering practice for new applications

INFECTIOUS WASTE LEGISLATION -- July, 1987

- Propose BACT incineration regulation by September 1, 1988
- New facilities comply 90 days after adoption
- Existing facilities comply by January 1, 1992

INFECTIOUS HOSPITAL WASTE CATEGORIES

- Surgical -- isolation
- Obstetrical -- isolation
- Pathological
- Biological -- isolation
- Blood and blood products -- isolation
- Serums and vaccines
- Renal Dialysis
- Laboratory -- pathogens
- Animal body parts -- pathogens
- Sharps

CONTINUOUS MONITORING

- Temperature
    - Primary combustion chamber
    - Secondary combustion chamber
    - Outlet
- Contaminants
    - Opacity
    - CO (for over 500 lb/hr charge)

STACK TESTING

- Frequency
    - Start-up
    - Annual
- Measurements
    - Particulates
    - HCl
    - CO
    - O_2

DATA AND CALCULATIONS

- Basic data
    - Waste
    - Design
    - Combustion air
    - Control
    - Gas cleaning
- Impact
    - Dispersion model
    - On and off site

OPERATOR TRAINING AND CERTIFICATION

- Training
    - Must submit program
    - Plant operation only by trained operators
- Certification mandatory when program implemented

INSPECTION AND REPORTING

- All components of facility
- Annual
- For DEC
- By P.E.

UNKNOWNS

- Particulates: Can existing facilities meet 0.015 gr/dscf at 7% O_2?
- HCl: Operational control?
- Opacity: Meet 10% all the time?
- CO: Meet 100 ppmv hourly average @ 7% O_2?

APPLICABILITY

- Type
  - New facilities
  - Proposed modifications
  - Existing
- Owners
  - Municipal/Private solid waste incineration facilities
  - Medical care facilities
  - Commercial facilities
- Size
  - Medical/Commercial: Under 50 tons/day
  - Municipal/Private: All

- Location: All of New York State
- Effective date: 90 days after promulgation, approximately February, 1989
- Criteria: PC issuance

EMISSION LIMITATIONS

- Particulate: 0.015 gr/dscf at 7% O_2
- HCl: 90% or 50 ppmv at 7% O_2

DESIGN REQUIREMENTS

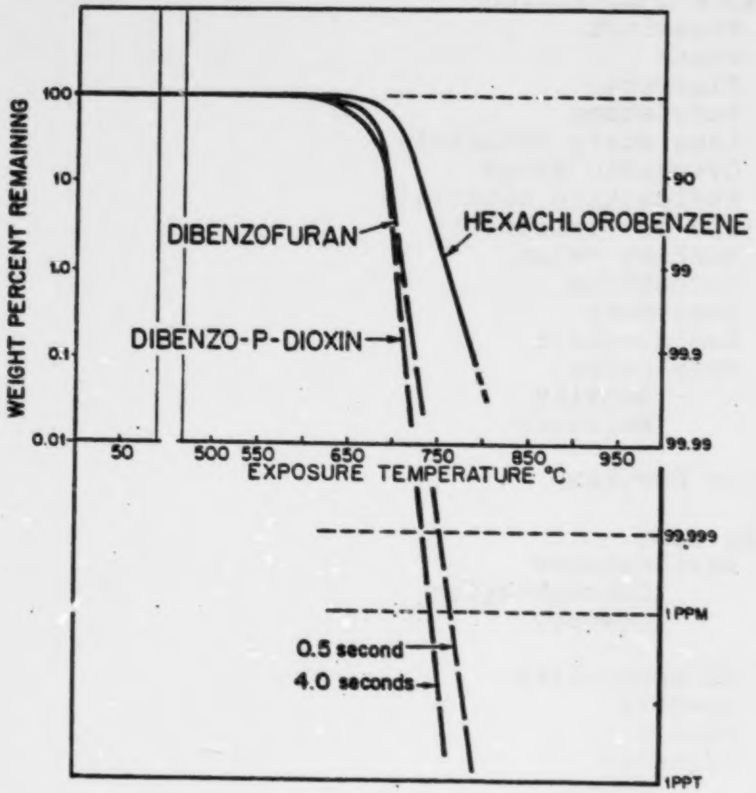
- Time/Temperature: At least 1 second at 1800° F or equivalent
- Auxiliary burner and interlocks: Designed to maintain 1 second at 1800° F secondary, 1400° primary
- HCl control: Outlet temperature less than 300° F or equivalent

OPERATING REQUIREMENTS

- Opacity: 10% (6 minute average)
- CO: 100 ppm (1 hour average)
- Temperature:
  - 1800° F secondary
  - 1400° F primary
  - 300° F outlet

OTHER WASTES

- Body parts
  - Up to 5%
  - Not identifiable in ash
- Radioactive: Needs 6 NYCRR 380 permit
- Hazardous: Needs 6 NYCRR 373 permit



KEY COMPONENTS

- Waste
- Hardware
- Air pollution control
- Operation

PROPOSED REGULATIONS

- Incinerators: Infectious Waste Incineration Facilities
  - 6 NYCRR Subpart 219-3
- Statutory Authority: Environmental Conservation Law
  - Sections 3-0301, 19-0301, 19-0303, 19-0306

HOSPITAL WASTE

- Variable composition
  - Dressings
  - Paper
  - Plastics
  - Bedclothes
  - Laboratory materials
  - Cytotoxic drugs
  - Radioactive materials
- Problems of variability
  - Heating value
  - Infectious
  - Hazardous
  - Radiological
  - Body parts
    - Density
    - Moisture

EMISSIONS OF CONCERN

- In the past
  - Particulates
    - Concentration
    - Opacity
- Now
  - Concentration
  - Opacity
  - Metals
  - Organics
    - Odors
    - Toxics (chlorinated)
    - Chemotherapeutic agents
    - Radioactive materials
    - Acid gases

PATHOGEN DESTRUCTION

- Limited data
- Gas emissions - 1800° F
- Ash - 1400° F

FOR AIR EMISSIONS, NON-INFECTIOUS = INFECTIOUS

- Concerns
  - Plastics (PVC)
  - Drugs
  - Radioactive
  - Pathogens
- Waste generally mixed
- Waste separation questionable

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233

Thomas C. Jorling
Commissioner

MEMORANDUM

TO: Regional Air Pollution Control Engineers
Bureau Directors
Section Chiefs
FROM: Mr. Hovey (Originator: W. Sonntag)
SUBJECT: Guidelines for Medical Care Waste-Incineration 88-AIR-21A
DATE: January 1, 1988

Background

On July 27, 1987, Articles 19 and 27 of the Environmental Conservation Law (ECL) were amended, relative to the management of infectious waste. For infectious waste incineration, this new legislation requires:

1. By September 1, 1988, proposal of a regulation requiring best available control technology.
2. Within ninety days of adoption of final regulation, compliance of proposed new incinerators with the regulation.
3. By January 1, 1992, compliance of existing incinerators with the new regulation.

These amendments to the ECL have resulted from a growing concern over the environmental impact of infectious waste disposal. The operators of both sanitary landfills and municipal waste incinerators have generally been unable to accept infectious waste. As a result, the red bags have, at times, piled up, representing a potential environmental problem.

Although the new legislation requires best available technology only for infectious waste incineration, it is the Department's position that such control should be required for all incineration of medical care waste (except garbage) for the following reasons:

- Concern with the burning of medical care waste relates to plastics, anticancer drugs and radioactive materials as well as pathogens;
- The proportions of the above materials of concern in non infectious and infectious medical care waste are approximately the same;
- Non infectious and infectious medical care waste are generally mixed;
- There is no way of knowing whether the waste going to the incinerator is infectious or non-infectious.

Existing Parts 219 and 222 were adopted in 1972 and 1973 to provide for the general regulation of refuse and pathological waste incineration. Part 222 applies in New York City, Nassau and Westchester Counties and Part 219 applies in the rest of the State. At the time of adoption, there was little concern with toxic emissions from these incinerators. Therefore, these regulations limit only emissions of particulate matter and smoke; Part 222 requires maintenance of 1400°F at the furnace outlet to destroy odors.

Purpose

The purpose for issuing this memorandum is to provide an interpretation of the legislative requirement for "best available control technology" for infectious waste incineration. The standards described here are expected to be proposed for regulation by September 1, 1988. This will be of value to medical care facilities planning to install incinerators. Adoption of the revised incinerator regulation, while subject to the public hearing process, is not expected to make obsolete, equipment installed in compliance with this program memorandum.

This guideline does not supplant Parts 219 and 222.

Permitting (Reference 6 NYCRR 617 and 621)

For uniformity of permitting new hospital waste incinerators throughout the State, employ the following procedures:

1. All applications for Permits to Construct are to be considered "Type I" or "unlisted" actions. Applications for replacement incinerators are not to be considered Type II actions based on the fact that they were approved according to the old Incinerator Institute of America classification of Types 0 to 4 waste, rather than "hospital" waste, which contains infectious material and significant quantities of chlorinated plastics.

2. All applications should be considered as having the potential for significant effect on the environment, based on Section 617.11(a)(1), (4), (5), (7). Therefore, a determination of environmental significance must be made carefully for each application. A public notice describing the proposed project and the determination of environmental significance should be placed in the Environmental Notice Bulletin for both "negative" and "positive declarations."

3. Strict adherence to Parts 617 and 621 must be assured by Regional DRA staff.

4. Municipal incinerators designed and operated in accordance with this program memorandum may also be eligible to burn hospital waste. If the facility owner so chooses, he should apply for a permit or permit modification, describing the waste to be burned. Such application should then be processed as described here.

Rationale for Standards to be Proposed

Particulate Matter

Best available particulate control technology for municipal waste incinerators has been defined by the DEC Advisory Board on Operating Requirements for Municipal Solid Waste Incinerators as 0.015 grains per dry standard cubic foot, corrected to 7 percent oxygen. This very low particulate concentration was based on:

- The need to collect small particles to which toxic organics may attach;
- The ability of current technology to provide that degree of control.

The same current technology is also available for hospital waste incineration. However, baghouses are likely to predominate, particularly for smaller installations. On this basis then, best available particulate control technology for hospital waste incinerators is 0.015 grains per dry standard cubic foot, corrected to 7 percent oxygen.

Temperature and Residence Time

Studies used in the development of a regulation for municipal refuse combustion have indicated that chlorinated plastics should be burned in an oxidizing atmosphere at a minimum of 1600°F for one second to assure the destruction of toxic organic compounds. This memorandum recommends that those parameters be met, but with a margin of 200°F as follows:

- For a two chamber incinerator, the average temperature/residence time in the secondary chamber alone should be at least 1800°F and one second. No credit for residence time may be taken for burning within the primary chamber.
- For a single chamber incinerator, such as a water tube boiler, the source owner should demonstrate by calculations and/or test data that the conditions of 1800°F and one second residence time are met within the combustion chamber.

Carbon Monoxide

The most widely accepted measure of complete combustion is carbon monoxide (CO). At the present time, indications are that CO concentrations of less than 100 ppm are attainable but the relationship of averaging time and charging method has not yet been fully explored. For this guidance, a CO value of 100 ppm hourly average, corrected to 7 percent oxygen (O_2), applies.

Loading and Operating Controls

Batch fed incinerators should incorporate an interlock system which will:

- Prevent charging until the secondary chamber exit temperature reaches 1800°F.
- Prevent recharging until the combustion and burndown cycles are complete.

Nonbatch fed incinerators should incorporate a mechanical loader and an air lock system to prevent opening the incinerator to the room environment. The volume of the loading system must consider the incinerator capacity to assure complete burning of the waste. Interlocks must prevent charging the waste until the secondary chamber exit temperature reaches 1800°F.

Auxiliary burners alone should be capable of raising the combustion chamber-exit temperature to a minimum of 1800°F. The firing rate of these burners should be modulated automatically to maintain this minimum temperature.

Acid Gas Control

The DEC Advisory Board on Operating Requirements for Municipal Solid Waste Incinerators has defined best available technology for hydrogen chloride control as 90 percent reduction or 50 ppm, exit concentration from incinerator whichever is less restrictive. A guideline for sulfur dioxide control has not been quantified because sulfur is not normally a significant component of either hospital or municipal waste. However, scrubbers that will provide 90 percent hydrogen chloride reduction may be expected to provide 60 to 70 percent sulfur dioxide reduction.

Equipment that will provide 90 percent hydrogen chloride reduction is readily available, using wet and dry scrubber and spray dryer technology. The allowable incinerator exit concentration of 50 ppm hydrogen chloride is to provide relief from the need to control very low emissions of hydrogen chloride.

Type 4 Waste

Because of its high density and moisture content, pathological (Type 4) waste will normally burn more slowly than hospital waste, making it more suitable for burning alone in a crematory. However, some hospital waste incinerators are designed to provide for the acceptable burning of Type 4 waste. For your guidance then, Type 4 waste may be burned with hospital waste only if the incinerator has been satisfactorily tested while burning that mixture. "Satisfactorily tested" means that the Type 4 waste must be completely destroyed and not be identifiable in the residue. Permits issued should restrict charging rates, by waste type, to the rates shown satisfactory by test.

Radioactive Waste

Both the products of combustion and the ash from burning radioactive waste are radioactive. Therefore, radioactive waste, whether decayed or not, may not be burned in an incinerator unless that incinerator has been permitted by the DEC Bureau of Radiation.

Continuous Monitoring and Recording

The secondary chamber exit temperature should be continuously measured and recorded to assure the maintenance of at least 1800°F. Flame from the auxiliary burner must not impinge on the thermocouples. Consideration is being given to the need for monitoring carbon monoxide and oxygen. Records should be submitted annually.

Opacity

Opacity should be limited to less than 10 percent during any consecutive six minute period except that a maximum of one six minute period per hour of less than 20 percent is allowed, as determined by EPA Method 9.

Calculations

Calculations and data, including references, should be provided relative to the following:

Waste - Provide the following information for each waste or mixture to be burned at one time (if all wastes are mixed uniformly, provide only once)

- Burning rate (maximum) - pounds per hour, tons per year
- Heating value of waste (maximum, average) (how determined), BTU/per pound
- Moisture (maximum, average), percent
- Pathological waste (Type 4), percent (by weight)
- Infectious waste (DOH designation), percent (by weight)
- Plastics, percent (by weight)

Incinerator and combustion air - Provide the following information for each waste or mixture to be burned at one time:

- Describe inlet and exit temperatures, residence times and flue gas velocities in each chamber. Residence time equals combustion chamber volume divided by volumetric flue gas flow at its average temperature.
- Describe anticipated excess/deficiency air requirements in primary and secondary chambers, percent.
- Describe combustion air flow, cfm and pressure drop, inches H_2O relative to fan provided.
- Demonstrate that flame from auxiliary burners will not impinge on thermocouples.

Impact of emissions -

- Provide dispersion model for particulate matter and HCl for both onsite and offsite receptors.

Testing

Because of its composition and attendant heating value, hospital waste does not conform to Type 0 through 4 waste used in the definition of "incinerator" in Part 200. Therefore, the existing list of DEC approved incinerators is invalid for the burning of hospital waste. Further, the inability of any incinerator to meet this guideline's particulate emission limitation makes an approved incinerator list meaningless. For those reasons, each facility in which hospital waste is to be incinerated should be tested while burning 100 percent hospital waste as a condition of the Permit to Construct. If the incineration facility is shown to be in compliance with the 0.015 grain per dscf guideline, no further particulate testing will be required. If the facility meets only the particulate limitation of Parts 219 or 222, further testing will be required when the forthcoming hospital incineration regulation is adopted. Obviously, failure to meet the particulate limits of Parts 219 and 222 will preclude the issuance of the Certificate to Operate.

Owners of incinerators burning hospital waste should provide results of measurements made at startup and annually thereafter, of carbon dioxide and carbon monoxide concentrations in the secondary chamber, to assess combustion efficiency.

Owners of incinerators burning hospital waste should provide results of measurements made at startup of secondary chamber: (1) inlet temperature (to evaluate average temperature and residence time) and (2) hydrogen chloride concentration (to evaluate the impact on receptors).

The Bureau of Toxic Air Sampling will continue to evaluate and maintain records of incinerator test reports.

All test methods must be acceptable to the Commissioner.

Operator Certification

In order to operate an incineration facility acceptably, all operators should be trained and certified by the equipment manufacturers or their designated representatives. Operators are to be knowledgeable with respect to:

- Proper operation and maintenance of equipment;
- Environmental permit conditions and the impact of plant operations;
- Operator safety.

Inspection

Experience has shown incinerator performance to be highly variable, depending on both operators and incinerator condition. These problems could be exaggerated in burning plastics. Therefore, an annual inspection report, attesting to the condition and operation of the incinerator and the calibration of instruments covered by this guidance, should be prepared by a qualified engineer and submitted to the DEC by the source owner. DEC staff should inspect annually each incinerator covered by this guidance against those inspection reports, while the incinerator is operating.

Summary of Guidelines

Applicability - New or modified incinerators burning waste (except garbage) from medical care facilities Statewide.

Permitting - Follow Part 617 and 621 - All actions "Type I" or "unlisted" - Publish in ENB.

Particulate Emissions - 0.015 gr/dscf at 7% O_2 (EPA Method 5).

Temperature & Residence Time - Secondary or single chamber design 1800°F and one second - Minimum 1800°F at exit.

Carbon Monoxide - 100 ppm hourly average at 7% O_2.

Loading and Operating Controls - Batch fed: interlocks for charging - Nonbatch fed: mechanical loader with interlocks - Modulating, auxiliary burners to raise and maintain secondary or single chamber exit temperature to 1800°F.

Acid Gas Control - Less restrictive of 90 percent HCl reduction or 50 ppm HCl.

Type 4 Waste - Pathological waste (Type 4) may only be burned with hospital waste if tested and found acceptable. Permits to limit wastes by type.

Radioactive Waste - Excluded unless permitted by DEC Bureau of Radiation.

Continuous Monitoring and Recording - Required to show secondary or single chamber exit temperature at least 1800°F. Possible need to monitor CO and O_2. Submit records annually.

Auxiliary Burners - Required to raise secondary or single chamber temperature to 1800°F and maintain there when needed.

Opacity - Hourly average less than 10 percent. Maximum continuous 6 minute average less than 20 percent.

Calculations - Waste composition and parameters, incinerator parameters, fan, impact analysis.

Testing - Particulates - test all units while burning hospital waste, at startup.

- Secondary chamber inlet temperature and HCl concentration - test at startup.
- Secondary chamber CO_2 and CO concentrations - test at startup and annually thereafter.

Operator Certification

- Proper operation and maintenance
- Permit conditions
- Operator safety

Inspection
- Annual report by owner.
- Annual review of report and inspection by DEC.

Attachment

cc: Regional Directors of Environmental Quality Engineering

87-2-80

HOSPITAL/INFECTIOUS WASTE MANAGEMENT

James M. Salvaggio
Pennsylvania Department of
Environmental Resources

Presented at:

**HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP**

Golden Gateway Holiday Inn
San Francisco, CA
May 10-12, 1988

BACKGROUND

LANDFILLING OF INFECTIOUS WASTE PROHIBITED

RECENTLY PROPOSED HOSPITAL/INFECTIOUS WASTE INCINERATORS

"Commercial"

Bedford County

* Application Submitted - 12/29/86
* Capacity - 600 lbs/hr.

MEGA

* Application Submitted - 7/8/87
* Capacity - 4000 lbs/hr.

On-Site "Captive"

SmithKline Beckman

* Application Submitted - 9/87
* Capacity - 750 lbs/hr.

Moses Taylor Hospital

* Application Submitted - 11/17/87
* Capacity - 167 lbs/hr.

LEGISLATIVE ACTIVITY

HOUSE RESOLUTION NO. 28

Legislative Hearings on Safety & Environmental Impact

HOUSE BILL 1387

One Year Moratorium on Incinerator Permits
    Mass Burn
    Infectious and Pathological Waste
    Refuse Derived Fuel

Local Municipality Override
    >150% of Local Need - Referendum

SENATE BILL 474

Comprehensive Plan
- Volume Waste
- Adequacy of Existing incinerators
- Geographic Location
- Siting Criteria

Expansion of Environmental Regulations

Moratorium of Permits

STATUTORY AUTHORITY

SECTION 6.1(A)

. . . No person shall construct, assemble, install or modify any stationary air contamination source . . . unless such person has applied to and received from the Department written approval . . .

SECTION 5.
ENVIRONMENTAL QUALITY BOARD

The Board shall have the power and its duty shall be to: (1) adopt rules and regulations, for the prevention, control, reduction and abatement of air pollution . . . regardless of whether such source is required to be under permit by this act.

SECTION 6.1(D)

The Department may refuse to grant approval . . . if it appears from the data available to the Department that the proposed source . . . are [is] likely to cause air pollution . . .

SECTION 3 (5)

Air Pollution. The presence in the outdoor atmosphere of any form of contaminant including but not limited to the discharging from stacks, chimneys . . . of smoke, soot, fly ash . . . gases . . . toxic or radioactive substances . . . in such place, manner, or concentration inimical or which may be inimical to the public health safety or welfare or which is, or may be injurious to human(s) . . . or which unreasonably interferes with the comfortable enjoyment of life or property.

REGULATORY AUTHORITY

NEW SOURCES

25 PA. Code Section 127.12(a)(4)

Show that the source will comply with all applicable requirements of this article and those requirements promulgated by the Administrator of the United States Environmental Protection Agency pursuant to he provisions of the Clean Air Act.

25 PA. Code Section 127.12(a)(5)

Show that the emissions from a new source will be the minimal attainable through the use of the best available technology.

25 PA. Code Section 127.1

Best Available Technology. Equipment, devices, methods, or techniques which will prevent, reduce or control emissions of air contaminants to the maximum degree possible and which are available or may be made available.

EXISTING SOURCES

25 PA. Code Section 123.12

No person shall cause, suffer or permit the emission . . . of particulate matter from any incinerator, at any time, in such a manner that . . . exceeds 0.1 grains per dry standard cubic foot, corrected to 12% carbon dioxide.

AIR QUALITY PROGRAM

NEW INCINERATORS

Administrative Hold on Issuance of New Incinerator Permits

June, 1987 until February, 1988

Permitting Criteria for Hospital/Infectious Waste Criteria

Best Available Technology Requirements

Operating Requirements

Ambient Impact Limitations

Monitoring, Testing and Record-Keeping Requirements

Operating Training Requirements

Compliance Assurance Plan

PURPOSE

Explains how we intend to ensure compliance with permitting criteria.

Communicates to industry what can be expected if permitting criteria are violated.

Establishes statewide, consistent enforcement response to violation of he permitting criteria.

CONTENTS

Permitting Process

Surveillance Activities
- Inspection Frequency
- Stack-Testing Schedule
- Continuous Emission Monitoring

Enforcement
- Penalty Provisions
- Mandated Shutdown Conditions

Local Coordination

EXISTING INCINERATORS

Concerns

Increased Reliance on Existing Incinerators

Adequacy of Existing Incinerators Unknown

Adequacy of Existing Incinerator Regulations

Unknown Number of Existing Incinerators

Action Plan

Upgrade Inspection of Previously Permitted Incinerators

- Estimate Residence Time and Temperature
- Estimate Emission
- Determine Adequacy of Equipment

Identify and Inspect Unpermitted Incinerators

Prepare Revised Regulations

Develop Compliance Assurance Plan

SUMMARY

Area of Considerable Public Interest

Adequate Statutory Authority

Regulatory Authority for New Incinerators is Adequate

In Process of Upgrading Regulatory Authority and Program Activities for Existing Incinerators

HOSPITAL/INFECTIOUS WASTE MANAGEMENT

Prepared by

PENNSYLVANIA DEPARTMENT OF ENVIRONMENTAL RESOURCES

OFFICE OF PUBLIC LIAISON

January 1988

INTRODUCTION

Waste generated in health care facilities such as hospitals, clinics, laboratories, pharmaceutical companies, health care practitioners and similar institutions may include infectious waste, small quantities of hazardous waste, chemotherapeutic wastes and general refuse. Bacteria, viruses and fungi in these wastes, if improperly stored, transported, processed or landfilled could be a danger to workers and the community at large. In addition, hospital-type waste has the potential to generate toxic air pollutants if improperly incinerated.

The Department regulates the handling and disposal of infectious waste -- any material that is suspected to be contaminated by disease-producing microorganisms or materials. This includes items such as bandages, discarded syringes, and laboratory apparatus as well as material such as body parts, specimens, and laboratory animal carcasses.

To minimize emissions from incinerators burning this combination of wastes, the Department regulates the burning of:

- **infectious waste** from any source; OR
- **any waste generated in hospitals or health care facilities**, whether or not it is infectious.

Summary of Provisions for Hospital/Infectious Waste Management

The Department has long required special handling of these wastes and has recently strengthened its regulations and policies to ensure safe handling of all wastes which have the potential to transmit disease. Requirements include:

- Storage and transportation of infectious waste more stringent than those applicable to ordinary municipal waste.

- Mandatory incineration of body parts, animal carcasses and similar wastes; waste blood may go to a sewage plant, but only if it provides adequate (secondary) treatment.

- Proper sterilization of infectious wastes before disposal, if they are not incinerated.

- New incinerators burning any hospital-type waste (including infectious waste) will be required to meet air quality standards which are among the most stringent in the country, as well as apply for a permit as a waste processor. This will allow the Department to examine the environmental suitability of the incinerator's location.

- No landfill can accept the sterilized infectious waste or ash from hospital waste incinerators unless DER has approved a specific permit modification. New rules will require that by the end of the decade all municipal waste landfills, including those accepting this waste, meet very stringent requirements such as a double liner.

The guidelines for air emissions from hospital/infectious waste incinerators were finalized on January 21, 1988. The new municipal waste regulations which govern handling of ash residue were approved by the Environmental Quality Board on December 15, 1987.

Public Involvement In Permit Decisions

The public participation process for waste processing, waste disposal and air quality permits are clearly defined in their respective laws and regulations. Since hospital waste incinerators must get both waste and air quality permits, the public participation procedure will be coordinated. At a minimum, procedures will include:

- notification of the community when the Department gets an application, along with publication of the notice in the Pennsylvania Bulletin;

- opportunity for a public hearing accessible to the host community; and

- publication of the permit decision;

Any final Department action is appealable to the Environmental Hearing Board.

The Department is committed to timely and meaningful public notification and input. To the extent of our legal jurisdiction, we are fully prepared to include in a permit's conditions those requirements we feel appropriate to address those concerns brought to us in a public forum, and will deny any permit application if necessary to protect health and safety.

PROVISIONS

INFECTIOUS WASTE HANDLING

The municipal waste rules presently contain general provisions to prevent waste storage areas and collection vehicles from causing health problems and nuisances such as odors, dust, and vectors (rats and insects which carry disease). The Department has strengthened those rules with special requirements for infectious and chemotherapeutic waste.

The new rules make it explicit that it is illegal to mix this waste in with ordinary garbage. Infectious/chemotherapeutic waste must be segregated and stored separately in labelled, distinctively-colored, closed and leakproof bags and/or containers in areas to which only authorized persons have access. Infectious waste can only be stored for one to three days depending upon waste composition (longer if refrigerated or frozen).

INFECTIOUS WASTE TRANSPORTATION

Requirements for hauling infectious waste are intended to prevent the release of disease-carrying organisms and to ensure easy identification in case of emergency. Existing regulations contain provisions addressing the safety of all municipal waste transportation. For example, trucks must be routinely inspected and cleaned. The drainage from equipment cleaning areas is also regulated to avoid water pollution from this runoff. The new rules make these requirements more explicit, and strengthen provisions for this special handling waste. While existing rules require labelled, leakproof, double bags and prohibit compaction of this waste, the new regulations specify the thickness of the double bags, and require infectious waste to be transported in separate, conspicuously identified trucks. Trucks must have a decontamination unit on board in case of emergencies.

Ash from incinerators must be transported in a covered vehicle. It is now and will continue to be illegal for a hauler to take sterilized infectious waste and incinerator ash to a facility that is not specifically authorized by the Department to accept it.

SAFEGUARDS FOR STERILIZATION

Present rules require that all infectious waste that is not incinerated be sterilized before disposal. Most often, this is done by the generator; unsterilized infectious waste then need not be trucked through a community.

The intention of sterilization is to kill all life stages of the pathogenic organisms. There are several approved sterilization methods using heat, steam, gas, chemicals or radiation. A processing facility must perform routine monitoring to ensure the sterilizer is working properly. It is illegal for waste processors/haulers to take waste to a disposal facility which is not specifically authorized to accept it.

The new rules specify that waste blood cannot be disposed of in a municipality's sewage treatment system unless the waste will receive secondary treatment.

REGULATION OF HOSPITAL WASTE INCINERATORS

Incineration continues to be the most effective and least costly way to process infectious waste; it also reduces the volume of waste that must be buried. All municipal waste incinerators are regulated by both air quality and waste processing regulations.

Air Quality

Many hospitals have their own incinerators. There are about 120 incinerators permitted for hospital waste in the Commonwealth, including 8 commercial facilities. Incinerators that were built before 1972 and never significantly modified are not required to have a permit, but must still abide by the Department's regulations for existing incinerators. These regulations prohibit visible emissions and set a limit for particulate matter. Usually, operating factors such as combustion chamber temperature are checked in an inspection as well to make sure the incinerators are operating properly.

The Department believes that new hospital waste incinerators **can and therefore should** meet more stringent standards. Pennsylvania's regulations (Chapter 127) require that all new air pollution sources reduce emissions as much as possible by employing "Best Available Technology" (BAT), which is based on the maximum degree of reduction continuously achievable for each pollutant, using available control techniques. In order to facilitate consistency in the review of permit applications, the Department has issued BAT criteria guidance documents for various source categories.

The Department's BAT guidance for hospital waste is among the most extensive and toughest in the nation. The criteria will be applicable to new and modified incinerators burning any hospital-type waste, whether or not it is infectious, AND to any waste that is suspected of being infectious, whether or not it is generated by a health care facility. As the name implies, the "best available" criteria will be revised as control technology improves. The Department may incorporate conditions more stringent than the BAT criteria into specific plan approvals, but in no case will the level of protection be less than that set forth in the criteria.

The BAT criteria document does not specify control devices, but describes the pollutant emission limits and operating practice requirements demanded of a new hospital waste incinerator. The BAT guidance is based on extensive evaluation of the capabilities and reliability of available process, pollution control, monitoring and testing technology.

The biggest concern the Department has with hospital waste incinerator emissions is not pathogens, which are destroyed by relatively low temperatures, but harmful chemicals produced by the combustion process. The BAT criteria are actually intended to keep the levels of these chemicals within the recommended guidelines.

The Best Available Technology criteria apply to new and modified new sources. This includes brand new facilities, as well as most incinerator modifications which might change or increase emissions or where the capital investment is over 50% of the cost of a new incinerator. (The BAT criteria for crematoria and animal hospitals will be determined on a case-by-case basis, incorporating appropriate requirements from the general guidance.) Facilities burning more than 50 tons of waste per day must also meet permitting conditions for municipal waste incinerators.

A proposed hospital waste incinerator must undergo a plan review before construction. The Department will examine its design to ensure all applicable standards are capable of being met, and then issue a permit and enforce that permit and operating standards.

Toxics Exposure. Of most concern to the public is the potential for toxic air chemical contaminant releases. Hospital wastes when burned improperly have the potential to release harmful organic pollutants such as dioxins. NO incinerator will be allowed to be constructed that cannot meet ambient air concentration limits for dioxins/furans, and for six heavy metals and their compounds (arsenic, beryllium, cadmium, hexavalent chromium, nickel, lead and mercury).

For potential carcinogens, the Department has used inhalation exposure levels based upon US Environmental Protection Agency Health Assessment Documents data that corresponds to a one in a million risk of a maximally exposed individual developing cancer. These risk estimates are likely to be higher than the actual risk because the worst case scenario is chosen at practically every juncture. For the two non-carcinogens, lead and mercury, the Department has used levels which are a small fraction of the Acceptable Daily Intake established by the federal Centers for Disease Control.

As with municipal waste incinerators, the Department will require owners of proposed hospital waste combustors to conduct ambient air impact analyses for these toxic pollutants. The analysis will predict the concentrations of pollutants in the air at ground level. The maximum concentration cannot exceed levels in the guidelines. Once the plant is operating, the assumptions made about the stack emissions must be verified by actual measurements, and tested periodically. Any problem causing an incinerator to exceed guideline levels for any one toxic contaminant must be corrected.

Temperature and Residence Time. High temperatures are essential in the secondary chamber of an incinerator to destroy the compounds in gases released during the burning of the waste. The BAT criteria requires a temperature of 1800 degrees Fahrenheit in the secondary chamber and for gases in the exhaust stack. Temperature must be monitored and recorded continuously.

Residence time refers to the length of time gases are held in the secondary chamber. A period of 2 seconds will be required, twice that for ordinary municipal waste incinerators. The longer residence time is to ensure complete destruction of gases that may be created by the high concentration of plastics in the waste stream.

Start-up and shut-down periods are critical times during operation. If the wastes are loaded before the unit has reached a high enough temperature, combustion won't be efficient and air contaminants could be released. The PA criteria prohibit any waste in the chamber until the required temperatures are reached. All wastes must be burned completely before the incinerator can be turned off.

Waste Loading and Combustion Chamber Charging. Problems in obtaining efficient burning of the waste often arise because the waste is loaded incorrectly. For example, too much waste will reduce the available oxygen needed to support combustion. Opening the door to a chamber while waste is being burned lowers the temperature, as any good cook knows. The BAT criteria contain two requirements addressing this problem:

- an interlock, which is a device preventing the charging of an incinerator unless the secondary chamber temperature is established and is holding at 1800 degrees.

- automatic loaders for all but the smallest units, to ensure that the combustion chamber cannot be overloaded and to prevent the door being opened during the cycle. (Small units generally are batch-fed, receiving a set amount of waste at one time rather than fed waste continuously.)

Stack Standards. Available new incinerators range in size from the very small, appropriate for an average hospital, to the large units more likely to be installed at a site taking waste from many different facilities. For nontoxic pollutants, the criteria contain different stack emission limits for each of three size classes of incinerators, based on the most appropriate technology for each. The emission limits become more stringent for the larger units, in some cases more stringent than those EPA requires for hazardous waste incinerators. ALL incinerators must meet the same toxic pollutant ambient impact analyses and operating requirements described above. This size distinction was adopted because:

- o many of the smallest units intended for on-site incineration would simply not be affordable to hospitals if the emission limits were more stringent for that class. There is a health and safety benefit to on-site incineration, because infectious waste never has to travel through the community.

- o emission limits are expressed in terms of concentration, which is usually measured as the number of molecules of pollutant for every million molecules of oxygen or other element in the exhaust. The total number of pollutant molecules may be no greater from a smaller facility even if the concentration limit is higher because there are fewer molecules of exhaust gas against which to count them.

The Department will require continuous monitoring and recording for many factors. This will not only give the operator instant information on emissions and other parameters but will give the permittee and the Department recorded data from which to diagnose and correct any operating problems, as well as on which to base enforcement actions.

It should be pointed out in discussing emission limits that a limit based on an average over a short period of time, like minutes and hours, is in effect much more stringent than one based on an average over a longer period of time.

For setting stack limits, incinerator classes are those with the capacity to burn: 1) under 500 pounds of waste per hour; 2) between 500 and 2000 pounds per hour; and, 3) over 2000 pounds per hour.

Carbon monoxide (CO): Minimizing CO indicates good combustion and also minimizes toxic organics. The BAT criteria for hospital incinerators are much more stringent than for other municipal waste combustors, since they prohibit more than 100 parts per million averaged over an hour. The municipal waste standard is 100 parts per million averaged over eight hours. The limit is the same for all classes, and continuous monitoring is required for all but the smallest units.

Combustion efficiency: This is a "redundant" measurement calculated from parameters (CO and Carbon dioxide) already required to be monitored for the largest sized units. The largest units must meet the very stringent combustion efficiency standard of 99.9 percent averaged hourly rather than the eight hour average for other municipal waste incinerators and monitored continuously. The oxygen corrected CO level can also effectively monitor combustion efficiency. The CO requirement of 100 ppm corrected to 7 percent Oxygen is equivalent to a combustion efficiency level of 99.9 percent.

Hydrochloric acid (HCl): Most states do not require controls on this acid gas. For the larger two classes and for municipal waste incinerators, the permitting criteria require no more than 30 parts per million (or a reduction of 90%). For the smallest class, HCl is measured differently, but limits are equal to that required of hazardous waste incinerators. Continuous monitoring is required for the largest class of units.

Sulfur dioxide (SO2): Except for the smallest units, a limit of 30 parts per million averaged hourly, or a reduction of 70%, is imposed.

Particulates: An excess of these small particles of solid material would indicate poor combustion, and would create a visible plume. Minimizing particulates also minimizes release of toxic metals. The largest units must meet the same standards as other municipal waste incinerators, .015 grains of particulate per dry cubic foot of exhaust gas. Mid-sized units must meet a .03 grain standard and smaller units a .08 standard, which is still equal to EPA standards for hazardous waste incinerators.

Opacity: Opacity is another indicator of good combustion. Zero opacity means the exhaust is invisible, while exhaust with 100% opacity would produce a thick plume of smoke. The opacity limit is the same for all classes, no more than 10% averaged over three minutes and never more than 30%. This must be monitored continuously in all but the smallest units.

Testing for Toxics: The largest hospital incinerators must test no Less often than every 6 months for the metals and every 12 months for dioxins. Mid-sized units must test annually for all toxics, while testing frequency for the smallest units will be determined by the Department individually.

Malfunctions. There are several factors which are so important to air quality that the Department is requiring that the feed to an incinerator (except batch-fed units) must be shut off if any one of them is exceeded for over 15 minutes: 1) temperature in the secondary chamber falling below 1800 degrees; 2) carbon monoxide over 150 parts per million; 3) flue gas oxygen below 6%; or, 4) opacity over 10%. The problem must be corrected before waste loading can continue.

The Department is to be notified immediately by telephone of equipment failure or other problems which result in emissions above requirements. The Department must be notified in writing within 5 days about these problems and the measures taken to correct them. It should be noted that any short-term increase in toxics at ground levels due to a 15 minute malfunction is so insignificant as to be unmeasurable in terms of increased risk to human health.

Operator Training. The Department will require applicants to submit the contents of operator training material for approval. Prior to start-up of the facility, the applicant must verify that its operators have been properly trained. Facilities cannot be operated by anyone that has not been so qualified.

The Department will also be developing a detailed enforcement strategy to specify the type and frequency of inspections, monitoring and test review procedures and specific actions the Department will take upon any violation.

Facilities already in existence are usually not required to retrofit to meet the same standards as new ones because the same technology for pollution control may not be available or would be immensely costly to install. However, the Bureau of Air Quality Control wants to assess any potential health risk in Pennsylvania due to emissions of existing hospital waste incinerators. The Bureau plans to visit every health care facility in the Commonwealth to locate and evaluate all hospital waste incinerators. The Department will then have the data to make a decision on whether it is necessary to revise regulations for existing hospital waste incinerators.

Waste Management

The existing municipal waste regulations contain detailed plan submission and operating requirements for waste processing facilities, including incinerators. Under current policy, the Department may also require submission of nonenvironmental socioeconomic information from waste processors to use in making its permitting decision. Of course, incinerators must abide by rules applicable to waste storage and transportation of ash.

In addition to requirements which run the gamut from insurance to signs, the new rules contain specific siting prohibitions for waste processors such as hospital waste incinerators: they cannot be located in a 100 year floodplain, within 300 feet of an important wetland, within 300 feet of an occupied dwelling without a waiver, within 100 feet of a perennial stream, and within 50 feet of the property line.

Under existing regulations, a log must be kept of the types and quantities of waste incinerated. Prior to initial disposal and periodically thereafter, ash sample analyses must be reviewed by the Department to ensure it is suitable for the intended disposal. Ash from all hospital incinerators (old and new) is considered a "special handling" waste and must be taken to a landfill that has an approved permit modification from the Department to take this waste.

Disposal of Infectious/Hospital Waste Incinerator Ash. Incinerator ash residue and sterilized infectious waste must be landfilled. Landfilling of properly sterilized waste from hospitals poses no more risk than other municipal waste. The amount of hospital-type waste being landfilled is small in proportion to the total amount of municipal waste. Hospital incinerator ash may be even less intrinsically harmful because it is unlikely ash will have processed tires, batteries, discarded paint and other problem household wastes. Recent studies seem to confirm that the ash from a properly operated incinerator contains no disease-producing microorganisms.

In approving an application for disposal of special handling waste, the Department will ensure that the disposal facility is making sure the waste has been properly processed. Many landfills approved to accept sterilized infectious waste require a waste tracking system even though it is not required by the Department.

An application for disposal of these special wastes must include a detailed description of the type and source of waste and of the sterilizing or incinerating process. The Department requires ash to be tested under conditions that simulate a landfill and may, if necessary, impose special disposal conditions in a permit to prevent leaching of heavy metals.

By the end of the decade, the Department intends that only landfills that meet the new stringent municipal waste disposal regulations continue to operate. Most design and operating requirements for these landfills will be similar to those for hazardous waste landfills. The new regulations require all landfills to be re-permitted within two years of the date the rules are effective. This means that even expansions at existing landfills will have to meet the stringent requirements for liners and leachate collection systems, waste sampling and recording, groundwater monitoring, financial responsibility, and the like. The only exceptions are that the Department cannot reasonably require waste already deposited to be excavated to install a liner or that an already operating facility meet many siting requirements. The Department will continue to require a special application from facilities to dispose of sterilized infectious waste and hospital incinerator ash.

1/21/88

BEST AVAILABLE TECHNOLOGY
AND
CHAPTER 127 PLAN APPROVAL CRITERIA
FOR
HOSPITAL/INFECTIOUS WASTE INCINERATORS

APPLICABILITY

This document specifies the plan approval requirements for hospital/infectious waste incinerator facilities including Best Available Technology (BAT) as required by 25 Pa. Code 127.12(a)(5). This document is not intended to be a comprehensive listing of the Chapter 127 requirements. Rather, it elaborates on selective provisions of Chapter 127. The applicable capacity refers to the facility rather than the individual unit. However the emission limitations are applicable to individual units.

This criteria is not applicable to crematory incinerators or incinerators located in any hospital or in any medical care facility if the units will be used to incinerate only general refuse, provided that the applicant demonstrates that the proposed incinerator will burn only general refuse and the infectious, hazardous, and chemotherapeutic wastes will be segregated and disposed of satisfactorily. The permitting criteria for such incinerators will be determined on a case-by-case basis incorporating the requirements of this Criteria as appropriate.

This Criteria will be periodically revised as control technology improves.

In addition to these applicable permitting requirements, facilities capable of burning hospital/infectious wastes at rates greater than or equal to 50 tons per day shall also meet the permitting criteria established for municipal waste incineration and resource recovery facilities capable of burning municipal wastes at rates greater than or equal to 50 tons per day.

DEFINITIONS

INCINERATOR - Any device specifically designed to provide the controlled combustion of wastes with the products of combustion directed to a flue as defined at 25 Pa. Code Section 121.1.

HOSPITAL WASTE - Wastes generated in any hospital or any health care facility or any pathological wastes (except for human and animal remains burned in a crematory incinerator), chemotherapeutic wastes or infectious wastes generated in any facility.

INFECTIOUS WASTE - Waste that contains or may contain any disease producing microorganism or material.

Infectious wastes include, but are not limited to, the following:

(a) Those wastes that are generated by hospitalized patients who are isolated in separate rooms in order to protect others from their severe and communicable disease.

(b) All cultures and stocks of etiologic agents.

(c) All waste blood and blood products.

(d) Tissues, organs, body parts, blood and body fluids that are removed during surgery and autopsy, and other wastes generated by surgery or autopsy of septic cases or patients with infectious diseases.

(e) Wastes that were in contact with pathogens in any type of laboratory work, including collection containers, culture dishes, slides, plates and assemblies for diagnostic tests; and devices used to transfer, inoculate and mix cultures.

(f) Sharps, including hypodermic needles, suture needles, disposable razors, syringes, pasteur pipettes, broken glass and scalpel blades.

(g) Wastes that were in contact with the blood of patients undergoing hemodialysis at hospitals or independent treatment centers.

(h) Carcasses and body parts of all animals which were exposed to zoonotic pathogens.

(i) Animal bedding and other wastes that were in contact with diseased or laboratory research animals or their excretions, secretions, carcasses, or body parts.

(j) Waste biologicals (e.g., vaccines) produced by pharmaceutical companies for human or veterinary use.

(k) Food and other products that are discarded because of contamination with etiologic agents.

(l) Discarded equipment and equipment parts that are contaminated with etiologic agents and are to be discarded.

CHEMOTHERAPEUTIC WASTE - All waste resulting from the production or use of antineoplastic agents used for the purpose of stopping or reversing the growth of malignant cells. Chemotherapeutic waste shall not include any waste containing antineoplastic agents that are listed as hazardous waste under 25 Pa Code Section 75.261 (relating to criteria, identification, and listing of hazardous waste).

HOSPITAL/INFECTIOUS WASTE INCINERATOR FACILITY - Any combination of hospital/infectious waste incinerators located on one or more contiguous or adjacent properties and which is owned or operated by the same person or by persons under common control.

CREMATORY INCINERATOR - Any incinerator designed and used solely for the burning of human remains or animal remains.

BEST AVAILABLE TECHNOLOGY REQUIREMENTS

A. Emission Limitations

1. **Facilities with capacity $\leq$500 lbs/hr:**

   a. Particulate matter emissions shall not exceed 0.08 grain per dry standard cubic foot of exhaust gas, corrected to 7% O_2.

   b. Carbon monoxide (CO) emissions shall not exceed 100 ppmv, hourly average, corrected to 7% O_2 on a dry basis.

   c. Hydrochloric acid (HCl) emissions shall not exceed 4 lbs/hr or, shall be reduced by 90% (by weight) on an hourly basis.

   d. Visible air contaminants shall not be emitted in such a manner that the opacity of the emissions is equal to or greater than 10% for a period or periods aggregating more than 3 minutes in any one hour; or equal to or greater than 30% at any time.

2. **Facilities with capacity >500 lbs/hr and $\leq$2000 lbs/hr:**

   a. Particulate matter emissions shall not exceed 0.03 grain per dry standard cubic foot of exhaust gas, corrected to 7% O_2.

   b. Carbon monoxide (CO) emissions, as measured at a location upstream of the control devices, shall not exceed 100 ppmv, hourly average, corrected to 7% O_2 on a dry basis.

   c. Hydrochloric acid (HCl) emissions shall not exceed 30 ppmv, hourly average, corrected to 7% O_2 on a dry basis; or, shall be reduced by 90% by weight on an hourly basis.

   d. Sulfur dioxide (SO_2) emissions shall not exceed 30 ppmv, hourly average, corrected to 7% O_2 on a dry basis; or shall be reduced by 75% (by weight) on an eight-hour basis.

   e. Visible air contaminants shall not be emitted in such a manner that the opacity of the emissions is equal to or greater than 10% for a period or periods aggregating more than 3 minutes in any one hour; or equal to or greater than 30% at any time.

3. **Facilities with capacity >2000 lbs/hr:**

   a. Particulate matter emissions shall not exceed 0.015 grain per dry standard cubic foot of exhaust gas, corrected to 7% O_2.

   b. Carbon monoxide (CO) emissions, as measured at a location upstream of the control devices, shall not exceed 100 ppmv, hourly average, corrected to 7% O_2 on a dry basis.

   c. Hydrochloric acid (HCl) emissions shall not exceed 30 ppmv, hourly average, corrected to 7% O_2 on a dry basis; or, shall be reduced by 90% (by weight) on an hourly basis.

   d. Sulfur dioxide (SO_2) emissions shall not exceed 30 ppmv, hourly average, corrected to 7% O_2 on a dry basis; or shall be reduced by 75% (by weight) on an eight-hour basis.

   e. Combustion efficiency (C.E.) shall be at least 99.9 percent on a hourly basis, computed as follows:

$$\text{C.E.} = \frac{[CO_2]}{[CO_2] + [CO]} \times 100$$

   $[CO_2]$ = Concentration of carbon dioxide
   $[CO]$ = Concentration of carbon monoxide

   f. Visible air contaminants shall not be emitted in such a manner that the opacity of the emissions is equal to or greater than 10% for a period or periods aggregating more than 3 minutes in any one hour; or equal to or greater than 30% at any time.

B. Operating Requirements

1. The secondary chamber shall be maintained at a temperature of 1800°F. The temperature of 1800°F shall be maintained for at least 2 seconds with a minimum secondary chamber residence time of 1 second. The ducting between the secondary chamber and heat recovery system or the breaching and a portion of the stack (tertiary chamber) may if desired, be included for the residence time demonstration. The temperature exiting the tertiary chamber shall be maintained at 1800°F. A thermocouple shall be appropriately located to confirm the temperature. The auxiliary (secondary and tertiary) burners of the incinerator should be designed such that without the assistance of the heat content of the waste, a minimum temperature of 2000°F can be maintained for at least 2 seconds.

2. The firing of the burners and the combustion air shall be modulated automatically to maintain a secondary chamber exit temperature of 1800°F.

3. The incinerator shall be equipped with an automatic loader except for units with capacities less than or equal to 300 lbs/hr and equipped with the interlocks specified in paragraph B.4. However, a sealed feeding device capable of preventing combustion upsets during charging will be required for the units with capacity less than 300 lbs/hr.

4. For batch fed incinerators, interlocks should be provided to prevent charging until: (1) the secondary chamber exit temperature is established and holding at 1800°F; and, (2) the combustion cycle is complete.

5. For non-batch fed incinerators, the charging of waste to the incinerator shall automatically cease through the use of an interlock system if:

   a. The incinerator's secondary temperature drops below 1800°F for a 15 minute period, or

   b. The carbon monoxide emissions are equal to or greater than 150 ppmv, corrected to 7% O_2 on a dry basis for a 15 minute period, or

   c. The flue gas oxygen level drops below 6% (wet basis) for a 15 minute period, or

   d. The opacity of the visible emissions is equal to or greater than 10% for a period of 15 minutes.

OTHER CHAPTER 127 REQUIREMENTS

C. Ambient Impact Analyses

Ambient impact analyses shall be conducted for: a) arsenic and compounds; b) beryllium and compounds; c) cadmium and compounds; d) hexavalent chromium and compounds; e) lead and compounds; f) mercury and compounds; g) nickel and compounds; h) polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) expressed as 2,3,7,8 tetrachlorinated dibenzo-p-dioxin (TCDD) equivalents using toxicity equivalents factors (TEFs) described in Appendix A. Using available emission factors, the emissions from the facility shall be estimated and the analyses shall be conducted by performing dispersion modeling using the facility's exhaust characteristics. The analyses shall be conducted in accordance with the procedures stipulated in Appendix C.

If the application is subject to "Prevention of Significant Deterioration" (PSD) requirements, the analyses shall be conducted in accordance with the "Guidelines on Air Quality Modeling" dated January, 1983 (as revised). The applicant should discuss the modeling requirements with the Department prior to starting any modeling study.

The analysis must show that predicted concentrations do not exceed the following annual ambient concentrations. Levels exceeding these concentrations have been determined by the Department to be unacceptable.

Contaminants	Ambient Concentration ($\mu g/m^3$)
Arsenic and compounds	0.23×10^{-3}
Beryllium and compounds	0.42×10^{-3}
Cadmium and compounds	0.56×10^{-3}
Hexavalent Chromium and compounds	0.83×10^{-4}
Lead and compounds	0.50
Mercury and compounds	0.08
Nickel and compounds	0.33×10^{-2}
PCDD & PCDF expressed as 2,3,7,8 TCDD equivalents	0.30×10^{-7}

Compliance shall be verified by stack sampling as described in paragraph F. Using the actual stack emission rates, the exhaust parameters from each test and the dispersion modeling techniques specified in the application as approved by the Department, the calculated maximum annual ambient concentrations shall not exceed the above levels.

D. Monitoring Requirements

The primary chamber temperature and secondary chamber exit temperature shall be continuously measured and recorded. Sensors shall be located such that flames from the burners do not impinge on the sensors.

Incinerators with a capacity larger than 500 lbs/hr shall be equipped with instruments for the continuous monitoring and recording of O_2, CO and opacity. Continuous monitoring and recording for CO_2, is also required for facilities with a capacity greater than or equal to 2000 lbs/hr.

The Department reserves the right to require the owner/operator of facilities with a capacity less than 2000 lbs/hr, to install SO_2 monitors at a time after the initial compliance tests if it is determined to be necessary. The Department also reserves the right to require facilities with a capacity greater than 2000 lbs/hr, to install HCl and SO_2 monitors at any time if it is determined to be necessary.

The O_2, CO and CO_2 monitors, when required, shall be co-located upstream of the air pollution control devices. If the applicant chooses to comply with SO_2 and HCl emission limitations by meeting the 75% and 90% reduction requirement, the SO_2 and HCl monitors, when required, shall be located upstream and downstream from the air pollution control device. If the applicant chooses to monitor the two locations with a single detector, the two locations should be sampled at an interval acceptable to the Department.

Continuous monitoring shall be conducted in accordance with 25 Pa Code Chapter 139 and be approved by the Department.

The Department reserves the right to require, at a later date, the owner/operator to provide telemetering of continuous monitoring data to the Department.

E. Start-up and Shut-down Requirements

No waste shall be charged to the incinerator until equilibrium at the required temperature has been attained in the chambers. The control equipment shall be operational and functioning properly prior to the introduction of waste into the incinerator and until all the wastes are incinerated.

During shutdowns the required temperatures are to be maintained in the chambers using auxiliary burners until the wastes are completely combusted.

A detailed procedure for normal system start-up and shut-down shall be submitted as a part of the application for approval including the duration of preheat and burn-out cycles.

F. Testing Requirements

1. Facilities with capacity ≤500 lbs/hr:

Source tests shall be conducted for: a) particulate matter; b) HCl; c) CO; d) arsenic and compounds (expressed as arsenic); e) beryllium and compounds (expressed as beryllium); f) cadmium and compounds (expressed as cadmium); g) hexavalent chromium and compounds (expressed as chromium); h) lead and compounds (expressed as lead); i) mercury and compounds (expressed as mercury); j) nickel and compounds (expressed as nickel); and k) PCDD and PCDF (expressed as 2,3,7,8 TCDD equivalents).

The Department reserves the right to require the owner or operator to conduct further source tests at any time if it is determined to be necessary by the Department after the initial compliance tests.

2. Facilities with capacity >500 lbs/hr and ≤2000 lbs/hr:

Source tests shall be conducted for: a) particulate matter; b) HCl; c) CO; d) SO_2; e) arsenic and compounds (expressed as arsenic);

f) beryllium and compounds (expressed as beryllium); g) cadmium and compounds (expressed as cadmium); h) hexavalent chromium and compounds (expressed as chromium); i) lead and compounds (expressed as lead); j) mercury and compounds (expressed as mercury); k) nickel and compounds (expressed as nickel); and l) PCDD and PCDF (expressed as 2,3,7,8 TCDD equivalents).

The owner or operator shall conduct source tests at any time or interval of time as may be prescribed by the Department. At a minimum, source tests shall be conducted for the above specified pollutants every year. As a data base is established and the emissions consistently show compliance the schedule may be altered.

3. Facilities with capacity >2000 lbs/hr:

Source tests shall be conducted for: a) particulate matter; b) HCl; c) CO; d) SO_2; e) arsenic and compounds (expressed as arsenic); f) beryllium and compounds (expressed as beryllium) g) cadmium and compounds (expressed as cadmium); h) hexavalent chromium and compounds (expressed as chromium); i) lead and compounds (expressed as lead); j) mercury and compounds (expressed as mercury); k) nickel and compounds (expressed as nickel); and l) PCDD and PCDF (expressed as 2,3,7,8 TCDD equivalents).

The owner or operator shall conduct source tests at any time or interval of time as may be prescribed by the Department. At a minimum, source tests shall be conducted:

a. For all pollutants specified in F.1 of this criteria except PCDD and PCDF - every six months, and

b. For PCDD and PCDF - every year.

c. For HCl and SO_2 (if monitors are required) - as required by the Department for the initial certification and system performance audits of the continous monitors.

As a data base is established and the emissions consistently show compliance the schedule may be altered.

All tests are to be conducted in accordance with the Department's source testing procedures described in "Source Testing Manual, Revision No. 1" (as revised) dated January, 1983. Source testing procedures are to be approved by the Department prior to testing.

G. Record Keeping and Reporting Requirements

Continuous emission/parameter data gathered from the monitors shall be submitted to the Department quarterly. The data shall be retained for at least two (2) years following the date of record and shall be made available to the Department during facility inspections.

The Department shall be notified by telephone immediately following any failure of process equipment, failure of any air pollution control equipment, failure of any monitoring equipment, or a process operational error which results in an increase in emissions above any allowable emission rate. In addition, the Department shall be notified in writing of the problem and measures taken to correct the problem as expeditiously as possible but no later than five (5) days following such failure.

H. Operator Training Requirements

Prior to the start-up, all incinerator operators shall be trained by the equipment manufacturers' representatives and/or another qualified organization as to proper operating practices and procedures. The content of the training program shall be submitted to the Department for approval. The applicant shall submit a copy of a certificate verifying the satisfactory completion of a training program prior to issuance of the operating permit. The applicant shall not operate the incinerator without an operator who has satisfactorily completed the training program.

I. General Application Requirements

The plan approval application shall include a description of each specific waste and approximate quantity of each such wastes which will be charged to the incinerator. The application shall, as a minimum, contain the final design specifications of the incinerator and the associated air pollution control devices with dimensioned drawings indicating the locations of burners, air injection ports and monitors. The application shall also include an estimate of potential and actual emissions of the non-typical air contaminants. These contaminants shall include: a) HCl; b) PCDD and PCDF (expressed as 2,3,7,8 TCDD equivalents (estimated as potential and actual emissions)); c) arsenic; d) beryllium; e) cadmium; f) hexavalent chromium; g) nickel; h) lead; and, i) mercury. The application shall also include a set of calculations for estimating secondary chamber residence time using the procedures contained in Appendix B and the results of ambient impact analyses conducted using the modeling procedures contained in Appendix C.

Approved by:

James K. Hambright, Director
Bureau of Air Quality Control

January 21, 1988

APPENDIX A

2,3,7,8 - TCDD Toxicity Equivalence Factors (TEFs)

Homologue/Congener	TEF
Mono through trichloro dioxins and Dibenzofurans	0
2,3,7,8-TCDD	1
Other TCDDs	0.01
2,3,7,8-PeCDD	0.5
Other PeCDDs	0.005
2,3,7,8-HxCDDs	0.04
Other HxCDDs	0.0004
2,3,7,8 HpCDDs	0.001
Other HpCDDs	0.00001
OCDDs	0
2,3,7,8-TCDF	0.1
Other TCDFs	0.001
2,3,7,8 PeCDFs	0.1
Other PeCDFs	0.001
2,3,7,8-HxCDFs	0.01
Other HxCDFs	0.0001
2,3,7,8-HpCDFs	0.001
Other HpCDFs	0.00001
OCDFs	0

APPENDIX - B

RESIDENCE TIME CALCULATION GUIDANCE

The review of all incinerators shall include verification of the residence time stated on the application. This guidance shall be followed to assure that these calculations are handled in a uniform manner.

STEP 1. Estimate the total heat input to the system:

Total system heat input (Btu/hr) = [Maximum waste firing rate (lbs/hr) x Maximum heating value (Btu/lb)] + Average primary burner heat input + Average secondary burner input.
Note: Use the average burner inputs required after the onset of waste burning.

Use a waste heating value of 8500 BTU/lb.

STEP 2. Estimate the system heat loss (prior to heat recovery):

System heat loss = Shell loss + sensible heat in ash + sensible heat in unburned carbon + latent heat.

The heat loss may be assumed to be 20% of total heat input.

STEP 3. Calculate the net heat available (Q) to raise the temperature of the products of combustion:

Q (Btu/hr) = (Total system heat input) - (system heat loss)

STEP 4. Calculate the weight of product of combustion (M)

$$M = Q/\{C_p \times (T_o - T_i)\}$$

C_p = average specific heat (Btu/lb °F), assume a value of 0.28.
T_o = exit temperature (°F), use the design temperature of 2000 °F as T_o.
T_i = ambient air temperature (°F), assume the ambient temperature to be 70°F.

STEP 5. Calculate the volume of product of combustion (F):

$$F(\text{scfs}) = \frac{M}{d \times 60 \times 60}$$

d (lb/cu. ft.) = density of exhaust gases at 70°F, use a value of 0.075.

$$F'(\text{acfs}) = F \times \frac{(T_o + 460)}{530}$$

$$F' \text{ @ design temperature} = F \times \frac{2460}{530}$$

STEP 6. Calculate the volume of secondary chamber and tertiary chamber (if tertiary chamber is included for the 2 second residence time demonstration). Tertiary chamber is the area between secondary chamber and heat recovery system or breaching area/part of the stack.

STEP 7. $\text{Residence time} = \frac{\text{Chamber volume}}{F'}$

For a minimum 1 sec secondary chamber residence time,

$$\frac{\text{secondary chamber volume}}{F'} = >1$$

For a minimum 2 sec @design temperature 2000°F,

$$\frac{\text{secondary + tertiary chamber volume}}{F'} = >2$$

APPENDIX C

DISPERSION MODELING PROCEDURES

I. PROCEDURE FOR DETERMINATION OF STACK HEIGHT ADEQUACY AND BUILDING INFLUENCES ON STACK PLUME DISPERSION

In the absence of any outside interference on the dispersion of stack plumes, the PTPLU dispersion model can be used to make a conservative screen of ground level concentration. Most of the time influences do exist, and they must be considered. First the building or buildings of potential influence must be determined. When more than one building is likely to influence the stack plume dispersion, the controlling influence needs to be determined. Except in infrequent cases the determination of potential building influence shall be made of buildings on site at the facility.

The building influence can be determined as follows:

A. DETERMINE POSSIBLE BUILDING INFLUENCE:

1. Determine the height (H) and projected width (W) of the tallest building at the facility.
2. Draw a circle with a radius of 10 H or 10 W (whichever is less) around the building.
3. Disregard any possible building influence if the stack is not within the circle, as determined in step 2, above.
4. Working closer to the stack from the distance of the tallest building, repeat steps 1, 2, and 3 above to determine which other buildings may also exert an influence on the stack.
5. If no buildings are considered significant enough to exert an influence on the stack, skip the remaining sections in this APPENDIX and use METHOD A for dispersion modeling.

B. DETERMINE BUILDING CAVITY HEIGHT:

1. Calculate the building cavity height (H_C) for all significant buildings (found by the procedure in Section A) by use of the following formula:

   $H_C = H + 0.5\ L$, where L is the lesser of the building height or projected width.

2. Select the building with the largest cavity height as the one which would exert the greatest influence.

C. CHECK STACK HEIGHT ADEQUACY:

1. Check to insure that stack design would not obstruct good dispersion of substance (i.e., no rain caps, elbows, etc.).

2. If the physical stack height is greater than Hc, and if the distance of 10 L (the building wake region) does not extend beyond the plant boundary, skip the rest of the appendix,go to page C-4 and use METHOD A.

3. Calculate the effective stack height, H_e, using the following formula:

   $H_e = H_s + H_m$ where H_s is physical stack height and H_m is momentum plume rise calculated by the following equations (Ref: Regional Workshops on Air Quality Modeling: Summary Report, EPA-450/4-82-015, Appendix C, page C-2, (Amended October 1983)):

$$H_m = \left[\frac{3 F_m(x)}{b^2 u^2} \right]^{1/3}$$

where b = ($1/3 + u/v_s$),
u = critical wind speed (m/s), (assume 7.5 m/s)
x = downwind distance (m) (assume 2 building heights or projected widths downwind, whichever is less),
F_m = momentum flux =(T_a/T_s) $V_s{}^2{}_* d^2/4$
T_a = ambient air temperature (^oK) (assume 293^oK),
T_s = stack exit temperature (^oK),
V_s = stack exit velocity (m/s); and
d = stack inner diameter (m).

4. If H_e is greater than H_c and if the distance of 10 L (the wake region) does not extend beyond the plant boundary, skip the rest and use METHOD A found in page C-4.

5. Go to page C-4 and use METHOD B for all remaining cases.

The PTPLU-2 dispersion model (METHOD A) may be used for screening if: (1) there are no building influences predicted by the procedure in Section A above, or (2) the stack height is adequate and there are no building wake effects beyond the property line (according to Section C above).

II.DISPERSION MODELING PROCEDURES

For screening purposes, the PTPLU dispersion model may be used for evaluation of point sources in cases where no building influences are expected. Some judgement must be made, however, in cases where stack designs (rain caps, elbows, etc.) may result in poorer dispersion. Where building influences may be of concern, as determined earlier, conservative estimates of the maximum ground level annual ambient concentrations within a building cavity region or building wake effect region should be made and compare these values with the acceptable ambient concentration for the substance.

METHOD A: [PTPLU-2(Version 6 from EPA UNAMAP) Model)]

1. Use the following assumption: Ambient temperature 293°K, mixing height 1500 m, and a receptor height of 2m.

2. Enter the stack parameter data in metric units: stack temperature (°K), stack flow (m^3/sec), stack area (m^2) and the emission rate (g/sec).

3. The model will predict hourly ground level concentrations for the substance (µg/m^3) for each of six stability classes at various downwind distances from the stack.

4. Determine the maximum hourly concentration predicted and convert this value to an annual concentration by multiplying the hourly concentration by a factor of 0.15.

METHOD B (Building Influences):

1. For building cavity situations, as determined in APPENDIX C-1 calculate the maximum ground level concentration (in µg/m3) expected in the cavity by the formula:

$$X(\text{conc.}) = \frac{Q*10^6*0.15}{1.5*U*A}$$

where X = the maximum annual concentration (µg/m^3),
Q = is the emission rate (g/sec),
U = the wind speed (m/sec),
A = the building area (height of building times its projected width) (m^2); and
1.5 is a coefficient recommended by EPA.

2. For building wake effect regions extending beyond the facility property line, as determined in APPENDIX C-1, calculate the maximum ground level ambient concentration (µg/m^3) in the wake effect region by using the ISCST model with representative "worst case" meteorological conditions [refer to Regional Workshops on Air Quality Modeling: A Summary Report, EPA-450/4-82-015, Appendix C, pages C-4 through C-6 (amended October 1983) for guidance].

3. If predicted values of "X" exceed the acceptable ambient concentration in either Step 1 or 2, the applicant shall use dispersion models approved by the Department.

GUIDELINES FOR THE HANDLING AND DISPOSAL OF BIOMEDICAL WASTES FROM HEALTH CARE FACILITIES AND LABORATORIES

John Manuel
Waste Management Branch
Ministry of the Environment

Presented at:

HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP

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INTRODUCTION

The title of these guidelines has been changed to reflect current usage. Previously the terms "pathological" and "institutional" were used to refer to what is now accepted to be "biomedical" waste. The term "biomedical" waste used throughout these guidelines now includes pathological waste, infectious waste, hazardous waste, and other waste generated in health care facilities and laboratories that requires special handling.

Some years ago, two separate groups in Metro Toronto became concerned about existing practices of waste disposal from hospitals and veterinaries. The Ontario Hospital Association was concerned about the increasing amounts of biomedical waste being generated by hospitals and also by the fact that existing hospital incineration facilities were rapidly becoming overloaded. At the same time, Metro Toronto public health officials were concerned about the limited biomedical waste disposal facilities available in the community.

These guidelines for the handling and disposal of biomedical waste supersede the February, 1982 edition of the Ministry of the Environment guidelines for the handling and disposal of pathological wastes and institutional wastes. These new guidelines cover the special precautions associated with the handling, storage, collection, transportation and disposal of biomedical waste from health care facilities and laboratories. The guidelines have been developed to minimize the risk of adverse environmental effects and the risk to public health in Ontario. Non-hazardous waste from offices, kitchens and mechanical plant which does not require special handling is not considered biomedical waste.

The 1986 guidelines should be followed unless other measures taken are directed, or expressly permitted, by other applicable Ontario or Federal legislation. It should be noted that such other legislation may impose more stringent requirements which may be mandatory in nature.

Persons involved with the managing, handling, storing, transporting and disposing biomedical waste should become very familiar with Ontario Regulation 309 with respect to:

- Waste Management System Certificate of Approval
- Manifesting (transporting of waste)
- Ontario waste generator registration number
- Liquid discharging to a municipal sanitary sewer
- Landfilling of solid waste

These guidelines do not address the disposal of wastes from veterinarian facilities and animal care centres.

This document is based on Ministry of the Environment Policy #14-05

GUIDELINES FOR THE HANDLING AND DISPOSAL OF BIOMEDICAL WASTES FROM HEALTH CARE FACILITIES AND LABORATORIES

1.0 DEFINITION AND CLASSIFICATION OF WASTE

1.1 Biomedical Waste

Biomedical waste originates in health care facilities, doctors' offices, diagnostic and research laboratories and mortuaries. This waste may be hazardous to public health and may include anatomical waste such as human or animal tissue and body parts.

Biomedical waste for the purposes of these guidelines includes both pathological waste and infectious waste. Communicable diseases are defined in schedules of the Ontario Health Protection and Promotion Act 1983 and the Canada Animal Disease and Protection Act.

1.1.1 Pathological Waste

Pathological Waste is a waste that is any of the following:

(1) Human anatomical waste including any part of the human body with the exception of extracted teeth, hair, nail clippings and the like.

(2) Animal anatomical waste which is all or part of a carcass suspected of being infected with a disease communicable to humans or animals.

1.1.2 Infectious Waste

Infectious waste is waste of any type which is contaminated or suspected to be contaminated with the causative agents of infectious disease or their toxic products and capable of infecting or causing disease in susceptible individuals or animals exposed to them.

To be classified as "infectious", waste should not merely contain pathogens but should also be capable of transmitting infection. An understanding of the factors necessary for transmission of infection is useful in classifying waste as infectious.

Infectious waste may include:

(1) Human anatomical;
(2) Animal anatomical;
(3) Non-anatomical;
(4) Microbiological;
(5) Blood, blood products, and body fluids suspected to contain microbial agents of disease;
(6) Waste generated by patients in isolation (for communicable diseases).

1.2 Other Biomedical Waste Requiring Special Handling

Waste other than those biomedical waste categories described above may be generated from time to time and shall be disposed of properly. These are:

(1) Hospital and health care waste considered not to be infectious.

(2) Non-anatomical waste that has been decontaminated in a device approved for that specific purpose.

(3) Sharps (e.g. needles, scalpels, etc.).

(4) Radioactive waste, chemical and chemotherapy waste, and organic waste (solvents) are not included in these guidelines. Reference should be made to other publications dealing with the safe handling and disposal of these waste categories.

2.0 PACKAGING OF BIOMEDICAL WASTE

Biomedical waste generated in health care facilities and laboratories shall always be properly segregated, packaged and colour coded to facilitate further handling, storage, decontamination or transportation.

2.1 Human Anatomical Waste - RED BAG
- 3 mil. Thickness

(MOE Designated Type A Class 1 Waste)

Human anatomical waste shall be double bagged, inner bag separately closed, outer bag **RED** and labelled, and contents kept refrigerated. The bagged waste may be stored in a rigid outer container that is colour coded **RED** or contents identified with an appropriate tag or label, for ease of mechanical handling for transportation and disposal.

2.2 Animal Anatomical Waste, Infectious - ORANGE BAG
- 3 mil. Thickness

(MOE Designated Type A Class 2 Waste)

Infectious or contaminated animal anatomical waste shall be double bagged, inner bag separately closed, outer bag **ORANGE** and labelled with the approved biohazard symbol, and contents kept refrigerated. For ease of mechanical handling for transportation and disposal, the bagged waste may be stored in a rigid outer container that is colour coded **ORANGE** or the contents in the container identified with a tag or label stating that the "WASTE IS CONTAMINATED WITH AGENTS OF COMMUNICABLE DISEASE".

2.3 Non-Anatomical Waste, Infectious - YELLOW BAG - 3 mil. Thickness

(MOE Designated Type A Class 3 Waste)

Infectious or contaminated non-anatomical waste shall be double bagged, inner bag separately closed, outer bag **YELLOW** and labelled with the approved biohazard symbol. Infectious or contaminated liquids shall be placed in impact resistant, hard-shell, sealed containers prior to bagging. For ease of mechanical handling for transportation and disposal, the bagged waste may be stored in a rigid outer container that is colour coded **YELLOW** or the contents in the container identified with a tag or label stating that the "WASTE IS CONTAMINATED WITH AGENTS OF COMMUNICABLE DISEASE".

2.4 Sharps - Hard Shell Container - BLACK BAG - 3 mil. Thickness

Only rigid, hard shell containers shall be used to package or contain discarded sharps (needles, scalpels, etc.) prior to disposal. The sharps container shall be enclosed in double, **BLACK** opaque plastic bags of 3 mil. thickness. Such packaged sharps shall be segregated from other waste and shall not be compacted in a waste compactor. Corrugated cardboard boxes are not recommended for packaging discarded sharps.

2.5 Waste - Non-Infectious - BLACK BAG - 3 mil. Thickness

Hospital and health care waste requiring special handling and considered not to be infectious (excluding office, kitchen and mechanical plant waste). Waste requiring special handling shall be contained in double, **BLACK** opaque plastic bags of 3 mil. thickness and may be landfilled. This waste shall not be compacted in a waste compactor.

3.0 DISPOSAL OF BIOMEDICAL WASTE

3.1 Incineration

The following biomedical waste categories shall always be incinerated (except for 3.2) prior to disposal of the ash in a landfill.

3.1.1 Pathological Waste

- Human anatomical waste
  (see 1.1.1(1) and 1.1.2(1))
- Animal anatomical waste
  (see 1.1.1(2) and 1.1.2(2))

3.1.2 Infectious Waste

- Human anatomical waste
- Animal anatomical waste
- Non-anatomical
- Microbiological
- Blood, blood products and body fluids
- Waste of patients in isolation

3.2 Steam Decontamination (Autoclave)

An acceptable alternate treatment to the incineration of infectious non-anatomical waste is steam decontamination in an autoclave under conditions of steam pressure, steam temperature and exposure time defined in the Laboratory Safety Manual guidelines, Laboratory Services Branch of the Ministry of Health (Appended).

3.3 New Technology for Decontamination of Waste

Subject to the approval of the appropriate provincial authority, alternate means of decontaminating biomedical waste may be considered. Approval will be considered on a case-by-case basis. The Ministries of Environment, Health and Labour should be approached in this regard.

3.4 Disposal of Other Types of Biomedical Waste

3.4.1 Decontaminated Waste Requiring Special Handling

Non-anatomical waste that has been decontaminated in a device approved for that specific purpose may be landfilled. This decontaminated waste shall be contained in double BLACK opaque plastic bags of 3 mil. thickness. This waste shall not be compacted before disposal in a landfill.

3.4.2 Sharps (e.g. needles, scalpels, etc.)

Sharps should be handled and disposed of in a safe manner that will prevent injury and/or infection. This bagged waste shall not be compacted before disposal in a landfill.

3.4.3 Radioactive, Chemical, Organic Waste

(See 1.2.4)

3.5 Liquid Infectious Waste Disposal

When liquid infectious waste is discharged to the municipal sanitary sewer, Regulation 309 requires that the discharger be registered with the Ministry of the Environment. In special, high risk cases the liquid waste shall not be discharged to the sewer. It shall either be contained in a securely sealed unbreakable container or absorbed into a solid carrier and included with the solid infectious waste. High risk waste shall be incinerated.

3.6 Blood

Blood or blood products known, or suspected, or likely to contain agents of a communicable disease must be collected and decontaminated by means of an approved method, or incinerated. It is not acceptable to discharge any blood to the storm sewer and this practice is prohibited.

3.7 Waste - Non-Infectious - Requiring Special Handling

Non-infectious hospital and health care waste may be landfilled. This bagged waste shall not be compacted before disposal in a landfill.

4.0 RIGID OUTER CONTAINER - FOR UNTREATED PATHOLOGICAL OR INFECTIOUS BIOMEDICAL WASTE

Untreated (contaminated), bagged biomedical waste transported to an off-site incinerator or other disposal facility approved for the receipt of this bagged waste shall be transported in a hard shell container that is either a:

(1) tape sealed, disposable, heavy-duty corrugated cardboard carton fitted with an inner leakproof plastic liner. This carton must be fed into the incinerator unopened; or a

(2) reusable plastic or metal container with a tight fitting lid. The entire empty container and lid shall be decontaminated and washed after each use as described in the Laboratory Safety Manual. (See references).

The rigid, outer container shall be colour coded and carry the appropriate biohazard symbol and label. Only a carrier in possession of a valid waste system certificate of approval for biomedical waste transportation and in possession of an Ontario manifest form shall transport this untreated waste.

5.0 STORAGE OF BIOMEDICAL WASTE

When storage of biomedical waste is unavoidable in a health care facility, the following factors must be considered:

- Access shall be limited to authorized personnel.
- Integrity of the packaging maintained.
- Duration of storage.
- Temperature of storage.
- Security of storage area with particular reference to security from entry, tampering, and vermin.
- Identification of the storage area. The storage area should be clearly marked and kept remote from food services and other clean areas.

5.1 Refrigerated Storage of Anatomical Waste

Facilities that store anatomical waste, either human or animal, shall use a lockable, closed cold storage facility or a lockable, domestic type deep freeze unit in which the anatomical waste is accumulated prior to disposal by incineration. This waste shall be stored at a temperature of 4°C or lower.

6.0 PROTECTION OF PERSONNEL

The Occupational Safety Act administered by the Ministry of Labour and the Health Protection and Promotion Act administered by the Medical Officer of Health advise that personnel designated for the collection and/or segregation and/or packaging of infectious waste shall be fully informed of the potential hazard to health and shall be trained in the applicable handling procedures and necessary safety precautions. Employers shall advise their employees by letter which may be used to inform their personal physicians of the nature of their individual occupations and its particular hazards so that each physician will be alerted to the possibility of the patient contracting an occupational illness. Consideration shall also be given for appropriate immunization of all personnel handling infectious wastes. Hospitals, institutions, and operators of waste management systems shall conform to the legislation and accepted precautionary health care codes of practice.

7.0 ON-SITE DISPOSAL OF WASTE

The on-site handling and disposal of biomedical waste in hospitals, other institutions and laboratories is the responsibility of the administration. This responsibility may be delegated to the Infection Control Committee or other designated personnel. For smaller facilities, guidance may be provided by an existing governing organization.

8.0 OFF-SITE DISPOSAL - CARRIER'S CERTIFICATE

Any person engaged in the transportation of waste to a disposal site is operating a Waste Management System. The operator of a Waste Management System is subject to the Environmental Protection Act, RSO 1980, and Ontario Regulation 309, as amended, and other Provincial and Federal Acts and Regulations. Licensed biomedical waste haulers, holding valid Waste Management Systems Certificates of Approval issued by the Ministry of the Environment, shall not accept untreated pathological or infectious biomedical waste for transportation to an Ontario registered disposal site unless the biomedical waste is properly identified, packaged, colour coded, and the rigid outer container is colour coded and labelled with the approved biohazard logo and description of contents manifested in compliance with the Ontario manifest form requirements.

9.0 SHARING OF EXISTING INCINERATOR FACILITIES BY OTHER HOSPITALS

Recent amendments to Regulation 309 under the Environmental Protection Act permits the sharing of hospital incinerators by other hospitals. The use of any hospital incinerator is subject to the incinerator being capable of meeting current Ministry of the Environment emission criteria. Owners of exempted hospital incinerators must provide an annual report on the use and condition of the incinerator. (See Regulation 309.S26).

10.0 INTER-HOSPITAL TRANSPORTATION OF BIOMEDICAL WASTE

Inter-hospital transportation of biomedical waste for the purpose of incineration only may be permitted if a hospital owned vehicle is used for this purpose. The vehicle owner shall be in possession of a valid Waste System Certificate of Approval issued by the Ministry of the Environment for this specific restricted purpose.

Biomedical waste being transported between two health care facilities must be packaged and contained in a rigid outer container as specified in Section 4.0. The vehicle operator shall be in possession of a completed Ontario manifest form when transporting biomedical waste.

Ministry of the Environment
Waste Management Branch
February 1986

JM/bjb
1242R

REFERENCES

Ontario Occupational Health and Safety Act, RSO 1980.

Ontario Health Protection and Promotion Act, 1983.
  - CDC/NIH. 1984 Guideline on Biomedical Waste.

MOE Certificate of Approval. See Environmental Protection Act, RSO 1980. Sections 8, 24, 26, 27, 40, and 136(4)

Ontario Regulation 309, Ontario Gazette, September 28, 1985. General, Waste Management, under the Environmental Protection Act.

Transportation of Dangerous Goods Act (Canada).

Animal Disease and Protection Act (Canada), as amended.

Laboratory Safety Manual, 1982.
Laboratory Services Branch, Ontario Ministry of Health,

Canadian Standards Association, Standard CSA Z317.10-M1981, Handling of Waste Materials Within Health Care Facilities

A Guide for the Safe Preparation and Disposal of Antineoplastic Agents, Ontario Hospital Association, 1982.

Guidelines for the Handling of Recombinant DNA Molecules and Animal Viruses and Cells, 1980. Medical Research Council of Canada.

U.S.E.P.A. Guidelines for Infectious Waste Management, 1985.

Biosafety in Microbilogical and Biomedical Laboratories, 1984.

U.S. Department of Health and Human Services.

APPENDIX I

SAFETY PROCEDURES FOR PERSONNEL HANDLING INFECTIOUS WASTE

1. Personnel who are involved with the collection, segregation, packaging, storage, transportation or disposal of waste and who are accidentally exposed to potentially infectious materials via the percutaneous route, ingestion, or contamination of mucous membranes should:

   a) determine the source and content of the material involved;

   b) determine the details regarding any disinfection or sterilization of the material, before the exposure;

   c) complete the accident/incident report form attached;

   d) report this incident to his or her immediate supervisor;

   e) report this incident to an occupational health nurse or a physician;

   f) report this incident to the Ministry of the Environment if the incident occurs outside the institutional buildings or at the waste disposal facility.

2. Personnel who are involved in the collection, segregation, packaging, storage, transportation, or disposal of waste and who become ill following exposure to potentially infectious or toxic wastes should:

   a) report the illness to his or her immediate supervisor;

   b) report the illness to an occupational health nurse or a physician.

   Where this disease is reportable, the occupational health nurse or physician should report it to the local Medical Officer of Health of the health unit or municipality in which the person is resident. Reportable diseases are cited in the Regulations under the Health Protection and Promotion Act (Ontario) and the Animal Disease and Protection Act (Canada).

   NOTE: "via the percutaneous route", refers to the transfer of infectious or toxic material through the skin or puncture by needle, glass or stick, or contamination of cuts, abrasions, or scratches.

Instructions for Completing Accident Incident Report Form

The form should be completed by the operator/employee immediately after being involved in an accident/incident/spill resulting in his/her accidental exposure to waste infected with an agent of a communicable disease or where a spill of biomedical and infectious waste has occurred. A report should be made in all cases of accident involving injury and in all cases involving accidental exposure to infectious aerosols or exposure to cytotoxic or radioactive substances contained in the waste of health care facilities, laboratories and similar activities, and in the operation of waste handling and disposal systems and landfills.

A copy of the biomedical waste handling report should be submitted to the employer/public health nurse/personnel physician, as is appropriate. In case of personal injury, separate Workers' Compensation Board (WCB) forms must also be completed and submitted within 48 hours of the time of injury.

Ontario

Biomedical Waste Handling
Report on Personnel
Accident / Spill / Incident / Injury

Section A

Location of Accident	
Address	
City/Town	Prov./State
Date	Time of Occurrence

Name of Person Involved or Injured	
Address	
City/Town	Postal Code
Home Tel. No.	Business Tel. No.

Name of Employer	
Business Address	
City/Town	Prov./State
Postal Code	Telephone No.

Name of Person Incident Reported to:	Date & Time Incident Reported
Occup. Health Nurse/Physician	
Personal Physician	
Workman's Compensation Board	

Location of Accident / Spill / Incident / Injury

☐ Hospital Ward / Patient Area
☐ Hospital Laboratory
☐ Hospital Waste Collection
☐ Hospital Waste Storage
☐ Hospital Incinerator
☐ Hospital Autoclave
☐ Hospital Compactor

☐ Licensed Laboratory / SCS
☐ Lab. Autoclave
☐ Lab. Chem/Disintegrator
☐ Lab. Waste Collection
☐ Lab. Waste Storage

☐ Hauling / Transportation (Private)
☐ Incinerator (Private)
☐ Autoclave (Private)
☐ Transfer Station
☐ Landfill
☐ Equipment Maintenance
☐ Equipment Repair

☐ Road Accident
☐ Spill / Breakage of Container
☐ Bag Leak / Burst
☐ Explosion

Details of Accident / Spill / Incident / Injury

Incident; Hazard Involved

☐ Infectious
☐ Cytotoxic / Chemotherapy
☐ Chemical / Toxic
☐ Physical / Injury
☐ Radioactive
☐ Heat
☐ Steam
☐ Aerosol
☐ Explosion
☐ Other (Specify) ____________

Incident; Type

☐ Breakage
☐ Spillage
☐ Aerosol
☐ Ingestion
☐ Physical Exposure
☐ Other (Specify) ____________

Injury; Type

☐ Animal Bite
☐ Skin Penetration
☐ Self Inoculation
☐ Eye Accident
☐ Chemical Burn
☐ Superficial Injury
☐ Other (Specify) ____________

Incident; Equipment Involved

☐ Glassware
☐ Needle / Syringe / Scalpel
☐ Needle / Cutter / Container
☐ Autoclave / Oven
☐ Incinerator
☐ Chem/Disintegrator
☐ Hoist / Cart
☐ Container
☐ Waste Handling Device
☐ Compactor
☐ Truck / Vehicle
☐ Other (Specify) ____________

Injury Site on Person

☐ Hands
☐ Other Limbs
☐ Facial Areas, Mouth, Neck
☐ Eyes
☐ Other (Specify) ____________

Activity at Time of Incident

☐ Waste Reception / Preparation
☐ Waste Handling / Transportation
☐ Waste Storage
☐ Driving Vehicle
☐ Transfer Waste to / from Vehicle
☐ Loading Incinerator
☐ Loading / Emptying Autoclave
☐ Loading
☐ Other (Specify) ____________

Section B – Remedial Action Taken Following Accident / Incident

(This Section to be Completed by Employer)

As concerns employee(s):

As concerns incident:

Indicate MRC Level of Contamination, if known	A B C D E F	(See MRC Guidelines)

Describe nature of Biomedical Waste Involved:

Recommendations made:

Name of Employee(s) Involved:	Employee Signature	Date
	Supervisor / Employer Signature	Date

APPENDIX II

GUIDELINES FOR VEHICLES TRANSPORTING ANATOMICAL OR INFECTIOUS WASTE

1. Any person engaged in the hauling of waste to a treatment or disposal site is operating a WASTE MANAGEMENT SYSTEM.

2. The operator of a WASTE MANAGEMENT SYSTEM is subject to Ontario Regulation 309 and the Environmental Protection Act and other legislation. The vehicle owner and/or operator is required to be in possession of a valid Certificate of Approval issued by the Ministry of the Environment prior to operating any WASTE MANAGEMENT SYSTEM involving the hauling of biomedical waste.

3. In addition to the standards outlined in the above-mentioned legislation, and the Certificate of Approval, the operator hauling anatomical or infectious waste must conform to the requirements governing the handling, packaging and transportation of wastes outlined in CSA Standard Z317.10-M1981, "Handling of Waste Material Within Health Care Facilities".

4. All transportation vehicles hauling anatomical or infectious waste shall be specially designed to accommodate the special interest to be served by the vehicle. The following features shall be provided in the storage compartment:

   a) The storage compartment must be insulated and must be kept refrigerated at a temperature of 4°C or lower. The independent refrigeration system must continue to be operable even when the vehicle is parked or inoperable.

   b) Walls and floor shall be metal surfaced to ensure effective cleaning and disinfecting.

   c) The floor shall be sealed and leakproof. A liquid retaining lip shall be provided above the floor level at the door opening.

   d) No windows or ventilating openings shall be provided opening into the storage compartment.

   e) Only one lockable door shall be provided in the storage compartment.

   f) An interior light shall be provided.

   g) The approved biological hazard symbol shall be prominently displayed on the outside left and right vertical surfaces of the storage compartment consistent with the requirements of the legislation.

   h) The vehicle shall not be used for any other purpose than transporting biomedical waste and shall not be driven in any area other than is specified in the Ministry of the Environment Certificate of Approval.

5. The storage compartment door shall be kept locked at all times during transportation of waste or when the vehicle is parked, except for normal entry. Suitable holes shall be provided in the mating parts of the compartment door lock to accommodate, where necessary, the wire and seal used by the Medical Officer of Health having jurisdiction.

6. The operator, as a condition of approval, must develop an Accident/ Spill/Incident protocol and have it approved by the Ministry of the Environment. The protocol must specify disinfecting materials, other supplies and their quantities, stored in the vehicle cab for accident and spill clean-up, as well as a list of procedures and the reporting protocol. The protocol must be followed in the event of all accidents or spills that occur during handling or transportation. Staff must be specifically trained in the implementation of this protocol. All accidents or incidents must be reported to the responsible Medical Officer of Health and to the Ministry of the Environment, preferably on the same day and not later than 24 hours after the occurrence. A spill must be reported immediately.

7. All waste accepted for transportation shall be appropriately bagged in colour-coded bags and transported in hard shell, leak-proof containers to avoid spills.

8. On the conclusion of each day's work, the interior compartment of the empty vehicle shall be decontaminated following the procedure given in the Laboratory Safety Manual 1982, Ministry of Health. The vehicle compartment shall be kept locked while the vehicle is parked.

APPENDIX III

COMMON CONTAMINATED WASTES FROM HEALTH CARE FACILITIES AND MEDICAL LABORATORIES*

Culture dishes
Pipettes
Syringes and other sharps
Tissue culture bottles and flasks
Membrane filters in plastic dishes
Collection bottles, bags, cups, and tubes used in handling blood, urine, feces, saliva, exudates, or excretions
Micro-titer plates used for hemagglutination testing, complement fixation, or antibody titer
Slides and plates from immunodiffusion testing
Slides and cover slips from blood specimens or tissue or colony picking
Disposable gloves, masks, clothing, bedding
Swabs, capillary tubes, and spreaders used to take or transfer samples containing pathogens
Tubes, cards, tabs and assemblies used for diagnostic purposes to speciate enteric or other pathogens
Transfusion and dialysis equipment

* Source: "Draft Manual for Infectious Waste Management", U.S. EPA, SW-957, September 1982

APPENDIX V

TYPES OF INFECTIOUS WASTE

Experts in the biological safety field have concluded that infectious wastes can be classified in the following categories*. Certain of these wastes (e.g., biomedical wastes and sharps) are not necessarily always infectious, but they are included in the list because they should always be handled in accordance with prudent management practices that minimize the hazards and address the special problems of these wastes.

- isolation wastes
- cultures and stocks of etiologic agents
- blood and blood products
- pathological wastes, placenta
- other wastes from surgery and autopsy
- contaminated laboratory wastes
- sharps, needles, scalpels
- dialysis unit wastes
- dialysis unit wastes
- animal carcasses and animal body parts
- animal bedding and other waste from animal rooms
- discarded biologicals, pharmaceuticals
- contaminated food and other products
- contaminated equipment

* Source: U.S. Federal Register, December 18, 1978. Environmental Protection Agency, Proposed Rules, "Hazardous Waste Guidelines and Regulations"

SESSION VI: AGENCY REGULATIONS AND GUIDELINES

SUMMARY OF DISCUSSION (SAN FRANCISCO)

Q: What are the costs and practicality of telemetering at a facility?

A: (J. Salvaggio, PA DER) On larger size units, Pennsylvania will probably require that the data be telemetered back to the Department. As we get more of these facilities, we will have more data to process manually, which is time-consuming and subject to error. Pennsylvania would like to have automatic transfer of the data to the Department on a quarterly basis or more frequently, so we can review it and take the appropriate enforcement action.

Q: To comment on New York's particulate standard of 0.15 gr/dscf, Wisconsin now requires 0.1 for larger units. This standard is fairly easily achieved by baghouses. A recent 800 lb/hr dual unit in New York is going to be using baghouse and low-pressure-drop scrubber technology. The entire control equipment costs are $75,000-$100,000. This facility plans to meet New York emission limits quite easily. New York regulations appear to be right on the mark for BACT.

A: (Unidentified speaker) Manufacturers assert that it is still difficult to meet 0.15 gr/dscf when corrected for O_2/CO_2. The test data being generated in California and Ontario are useful because many agencies do not have funds for such research.

Q: California has received claims from incinerator manufacturers that they can meet 0.05 gr/dscf corrected.

A: (S. Shuler, Ecolaire Corp.) Such claims indicate poor judgment; 0.05 gr/dscf corrected without air pollution control equipment is unattainable.

Incinerators reviewed by California seem to be a fairly good cross section for determining what is achievable with or without air pollution control devices. It is not uncommon with Method 5 to attain 0.08 gr/dscf and in some remote conditions perhaps a little less. Because of liability and commercial constraints, one does not necessarily make this claim.

Q: Are you saying that outside of California people are not familiar with the drastic difference in the test method when you modify Method 5? You take an impinger catch and put an added filter on the rear end of the sample train.

A: (S. Shuler, Ecolaire Corp.) The problems are more far-reaching than that. Many applicants and reviewers do not have the experience to evaluate manufacturers' claims. Some small "mom and pop" firms do not have the technical capability to produce what is required.

(G. Yee, CARB) California shares this concern. An example is a facility that was built under a hearing board variance, and problems had to be addressed afterward. It is disconcerting to the customer to have to redesign the facility.

Q: At the Stanford facility, economics determined the choice of materials, but this may be short-sighted. The long-term plan is to replace some of the carbon steel components with stainless steel.

Q: Operator training and certification are definitely needed. The Waste Combustion Assistance Council would like a properly managed training and certification program. Some manufacturers have their own programs, but there is a high turnover of personnel at facilities. The operators are usually not technically-oriented individuals. This is equivalent to the situation in the boiler industry prior to licensing of operators. A modern incinerator is a fairly sophisticated device. Four technically-oriented certified people should be onsite around the clock.

A: (S. Hickerson, Emcotek) The problem is not just incineration and rules, but overall management of the waste. The difficulty in attaining reductions is not just the removal levels, but water handling and effluent management. Compliance officers should be more concerned in areas that are critical to how the controls will work in the long haul, whether it is a cyclic operation or a continuous one.

Q: Regarding residence time and temperature, it is important to have minimum design or operating criteria in the regulation. But meeting these criteria does not ensure complete combustion. In CARB tests, most of the incinerators have been designed to meet these criteria. However, toxics have still been detected at the stack. The research on which these criteria were based was directed at destruction and removal efficiency of the original compound and not at the possible products of reformation reactions. Conversion of the toxin to a different, stable compound is required.

Existing baghouses and scrubbers are not necessarily designed for controlling toxins. The efficiencies with toxins of these controls are fairly low to moderate for the ones CARB has tested. However, they are highly efficient in removing the types of pollutants they were designed for, e.g. particulates.

Q: Pennsylvania plans to test new incinerators for toxics (as often as every six months for larger units). Toxic testing is fairly expensive. How comprehensive a test will be required?

A: (J. Salvaggio, PA DER) Pennsylvania is permitting close to 40 units per year. The cost of repeated testing was of concern, yet testing was also one of the major concerns of the public. The waste supply will vary day to day. How can you be confident that what you are permitting and testing will be achievable over the life of that unit? The only way is to generate the data. We have not been able to identify an alternative way of developing the data base that gives us the assurance that what we are doing is in fact protecting the public health.

Pennsylvania will require the equivalent of an acceptance test on the larger units once every six months and on middle size units once every year. All the units have to do dioxin testing for the acceptance test, then once a year for all source sizes. Smaller units get an exemption once they meet the acceptance test. Units will be retested if there is a reason to suspect something, e.g. if there is a continual opacity problem.

Q: The costs of testing are extremely high. How much do we actually learn and where is the point of diminishing returns?

Q: Regarding Pennsylvania's policy of encouraging on-site incineration, California's experience on compliance testing which includes toxics monitoring is that the costs reach upwards of $80,000 per test. Doesn't this expense for an on-site facility discourage a waste generator from siting an incinerator?

A: (J. Salvaggio, PA DER) Yes. The original mandate was to push towards regional incinerators, but Pennsylvania learned as a result of the applications we were receiving that the public is just not ready to accept a regional incinerator. There was tremendous opposition to commercial facilities, so we wanted to provide some capability of on-site incineration and we included that in the regulation. We estimated the cost at about $35,000 per test, but the cost may decrease as more testing is conducted.

Q: Regarding Canada's color-coding for waste separation: in the United States, less separation is occurring as hospitals throw everything into red bags. What are the chances of success with five color coded categories?

A: (J. Manuel, ON Min. of Env.) Canada does not see any problem with multiple color bags because the colors are used in different facilities. Red bags in the U.S. are yellow in Canada. Blue bags are for veterinary use, red for tissue, and yellow for nonanatomical infectious waste. Sharps go into puncture resistant containers and then into the regular garbage can used with all the other wastes. The only difference is this bag of waste is not compacted and goes directly to the landfill. With all the precautions, there will be a much larger disposal of general waste into the red and yellow bags. The only solution is education of the hospital staff.

In 1985, the regulation required that all incinerators in hospitals had to report on the wastes they were burning daily. An annual report was required from each facility. Additionally, each facility was professionally assessed each year by a consultant who carries out the stack testing. The costs were enormous and the data were a waste of time. The consultants and engineers need education on how to do the testing. Even though the regulation required it, we abandoned this after one year because the costs were too high and it just doesn't work.

(D. Campbell, Env. Can.) One of the strongest driving forces behind the color coding in hospitals is a certification program. If hospitals follow the codes and guidelines that are issued by Ontario or the federal government it gives them points toward certification. They are certified each year. Some hospitals do not get full certification, but following the code guidelines is a way for them to get points.

SESSION VI: AGENCY REGULATIONS AND GUIDELINES

SUMMARY OF DISCUSSION (BALTIMORE)

Q: Turbulent mixing in typical incinerators seems to be non-optimal, and new designs or alternative technologies are needed to optimize overall combustion. Autoclaving should also be considered. Agencies should examine new burner designs which do not use a primary chamber burner online.

Q: Why did South Coast AQMD require a dioxin test when it otherwise sought to reduce costs and took care not to impose a financial hardship on small facilities? This could cause units of under 500 lb/hr to close.

A: (R. Pease, SCAQMD) The original intent was to have a regional facility built, but the facilities originally proposed were opposed at the local level. The public would not accept the uncertainty regarding whether and how much dioxin emissions would occur.

Costs differ between research testing and compliance testing. Agency policy is that if the risk analysis predicts a risk of less than 1 in 1 million, then the facility is allowed to test only for total dioxin and assume for impact analysis that all dioxin is 2,3,7,8 TCDD. If the risk is greater than 1 in 1 million, the analysis must consider homologues, isomers, etc. and may have to recalculate risk.

Q: What is the cost of a "screening" type test for total dioxin?

A: (R. Pease, SCAQMD) The cost is on the order of $10,000-$15,000 per unit.

SESSION VII

DISCUSSION GROUPS - CASE EXAMPLES

Sample Hospital Incineration Regulation
(for discussion group leaders)
Hospital Incineration Workshops - May, 1988

Please react to the following hypthetical model rule for permitting hospital waste incinerators. Provide applicability criteria (e.g., firing type, waste streams, characteristics, size of unit) to which the rule's provisions should apply. What additions and/or changes should be made?

HYPOTHETICAL MODEL RULE:

Item	Requirement
NEW/MODIFIED Units	Case by case BACT
EXISTING Units	
Temperature	1800F
Residence Time	2 sec
Design	good combustion and turbulence multi-chamber
Pollutants	
Metals (Cd, Cr, Pb, Hg, Ar)	Set specific limits as necessary or set specific limits (equivalency)
Dioxins/Furans	
CO	100 ppm (1 hr ave)
PM	0.015 g/dscf (12% CO or 7%02)
HCl	acid gas scrubbing
Pathogens (AIDS, hepatitis B)	no additional controls
Waste management/separation	containers for sharps,paper recycling
Stack height adjustments	for noncarcinogens only and downwash prevention
Source monitoring	temperature (primary and secondary) opacity, CO, 02
Operator procedures	certification, established O&M procedures
Stack testing	start-up, annual retest
Inspection/reporting	annual, source record keeping
Additional criteria	public hearings, worst case risk assessment

Hospital Infectious Waste Incineration
and Hospital Sterilization Workshops
May, 1988

Suggestions for Discussion Group Leaders

1. Do these cases include information that your agency requires in permits? process data? modeling data? site information? special conditions? What additional information does your agency require?

2. What special conditions do you currently require for infectious waste incineration? for sterilizers?

3. What do you expect to require in the near future (1-2 years) for new and existing sources?

4. What guidance (technical and policy) does your agency need to permit incinerators and sterilizers?

5. Policy guidance: Do you need general information on hospital waste disposal, e.g., disposal options, regional vs. local facilities? sample regulations? other?

6. Technical guidance: Do you need information related to emission control technologies, air toxics impacts, modeling determinations, etc.?

7. Is the issue of hospital waste similar or different to other stationary source permitting in your agency?

CASE I

Health Spot Hospital, Inc.

Permit to Install Application

General Description

Health Spot Hospital, Inc. (hereinafter "Health Spot") proposes to install an ethylene oxide (EtO) sterilizer to sterilize materials which will be used mainly in the operating room of the hospital. This sterilizer is basically an enclosed chamber into which these materials are placed and exposed to a mixture of EtO and dichlorodifluoromethane (Freon 12). When these materials are properly sterilized, the chamber is evacuated by a water-sealed vacuum pump and the materials removed and placed into a ventilated storage area for future use. The EtO/ Freon 12 gases from the vacuum pump are ducted to the side of the building and exhausted outside. In addition, there is a hood over the sterilizer to exhaust the EtO which remains in the chamber and a hood over the drain from the water-sealed vacuum pump to exhaust the EtO which was absorbed by the water in the vacuum pump. The cost of the sterilizer is $75,000.

Process Steps

The following are the process steps for a sterilization cycle:

1. The materials are placed into the sterilizer and the door is sealed.
2. The vacuum pump is turned on until a vacuum of 20" Hg is achieved.

3. Steam is added to achieve a 60 % relative humidity inside the chamber.
4. The EtO/Freon 12 gas mixture is pumped into the chamber and the chamber is heated to a temperature of 120 °F. A positive pressure of 7 psig is achieved. The materials remain under this condition for a period of 2-3 hours.
5. The vacuum pump is turned on and the chamber evacuated until a vacuum of 20" Hg is achieved. This takes about 30 minutes.
6. Ambient room air is allowed to bleed into the chamber until atmospheric pressure is achieved. This takes about 10 minutes.
7. The vacuum pump is again turned on and the chamber evacuated until a vacuum of 20" Hg is achieved. This takes about 10 minutes.
8. Ambient room air is allowed to bleed into the chamber until atmospheric pressure is achieved. This take about 10 minutes.
9. Steps 7 and 8 are repeated one more time.
10. The door is opened and the sterilized materials are removed and placed into a ventilated storage area for future use in the hospital.

Process Equipment Description

Sterilizer: 20 cubic feet gas capacity

Vacuum pump: 2 SCFM capacity (See Note 1)
Once-through water-ring design

Exhaust airflow: Hood over sterilizer: 200 SCFM

Hood over drain: 100 SCFM

Vacuum pump discharge: 16 feet above ground

2" diameter duct

Hood exhaust: Both airstreams combined to single discharge point

16 feet above ground

There is one fan for both hoods and both are operated simultaneously

6" diameter duct

Building height: 60 feet

Distance from building to sidewalk: 50 feet

Location of closest fresh air intake: on top of roof, 110 feet north of the vacuum pump discharge duct

Area designation: Nonattainment for ozone

Attainment for all other criteria pollutants

Note 1: While the vacuum pump has a rated capacity of 2 SCFM, it can only pump at this rate when there is either a positive pressure in the sterilization chamber or when the chamber door is opened. When the pump is actually creating a negative pressure (vacuum) in the chamber, the airflow diminishes in relation to the amount of vacuum in the chamber. When the vacuum pump creates a vacuum of 20" Hg, the airflow is essentially 0 SCFM. For the purposes of dispersion modeling, it is more appropriate to look at the total emission during a one hour period and modeling this as a building source, rather than modeling as a stack source with a constant airflow during that period.

Process Materials and Emissions

Maximum process operating schedule: 1 cycle / 8-hr shift

2 shifts / day

5 days / week

52 weeks / year

Sterilizing gas: Volume basis:

EtO: 27 % Freon 12: 73%

Weight basis:

EtO: 12 % Freon 12: 88%

Sterilizing gas usage per sterilization cycle:

EtO:	0.686 lb
Freon 12:	5.038 lb

EtO Emissions from sterilizer per sterilization cycle:

1. Emissions from vacuum pump (See Note 2):

Purge	Total air exhausted	Concentration	Amount
1st	22.89 ft³	203238 ppmv	0.484 lb
2nd	13.37 ft³	65233 ppmv	0.099 lb
3rd	13.37 ft³	21380 ppmv	0.033 lb

2. Emissions at end of cycle:

Amount in gaseous form in the chamber which is exhausted when the door is opened and the materials removed (captured by the hood over the sterilizer):

0.016 lb

3. EtO which remains in the materials which have been sterilized is slowly evaporated during the next several weeks in the ventilated storage area:

0.054 lb

EtO maximum ground level concentration:

See Note 3

1. Modeling assumed a continuous emission at the highest 1-hour emission rate.

Vacuum pump		Hoods
Annual:	3.0 ug/M^3	See Notes 2 and 4
24-hour:	18.0 ug/M^3	
8-hour:	31.0 ug/M^3	
1-hour:	45.0 ug/M^3	
10-min:	90.0 ug/M^3	

2. Modeling assumed an emission for 1 hour out of 8 hours.

Vacuum pump		Hoods
Annual:	0.4 ug/M^3	See Notes 2 and 4
24-hour:	3.5 ug/M^3	
8-hour:	6.0 ug/M^3	
1-hour:	45.0 ug/M^3	
10-min:	90.0 ug/M^3	

EtO maximum concentration at building intake:

See Note 5

1. Modeling assumed a continuous emission at the highest 1-hour emission rate.

Vacuum pump		Hoods
Annual:	15 ug/M^3	See Notes 2 and 4
24-hour:	90 ug/M^3	
8-hour:	155 ug/M^3	
1-hour:	225 ug/M^3	
10-min:	450 ug/M^3	

2. Modeling assumed an emission for 1 hour out of 8 hours.

Vacuum pump		Hoods
Annual:	2 ug/M^3	See Notes 2 and 4
24-hour:	17 ug/M^3	
8-hour:	30 ug/M^3	
1-hour:	225 ug/M^3	
10-min:	450 ug/M^3	

Note 2: In reality, approximately 15 % of the EtO is absorbed by the water in the water-sealed vacuum pump. However, with neutral pH water, the hydrolization of EtO to ethylene glycol for all practical purposes does not occur during the time that the EtO is in the water. Despite the high solubility of EtO in water, EtO will preferentially evaporate when the water is dumped in the drain. This is why a hood has been placed over the drain opening, so that this lost EtO will be exhausted outside rather than accumulating inside the sterilizer room. For the

purposes of the EPA conference, assume that all of this EtO is exhausted from the vacuum pump. As will be described at the conference, a small modification to the vacuum pump, so that there is total water recirculation, is a reasonable change which makes it technically easier to control this 15% of the EtO which would otherwise be exhausted through the hood located over the drain.

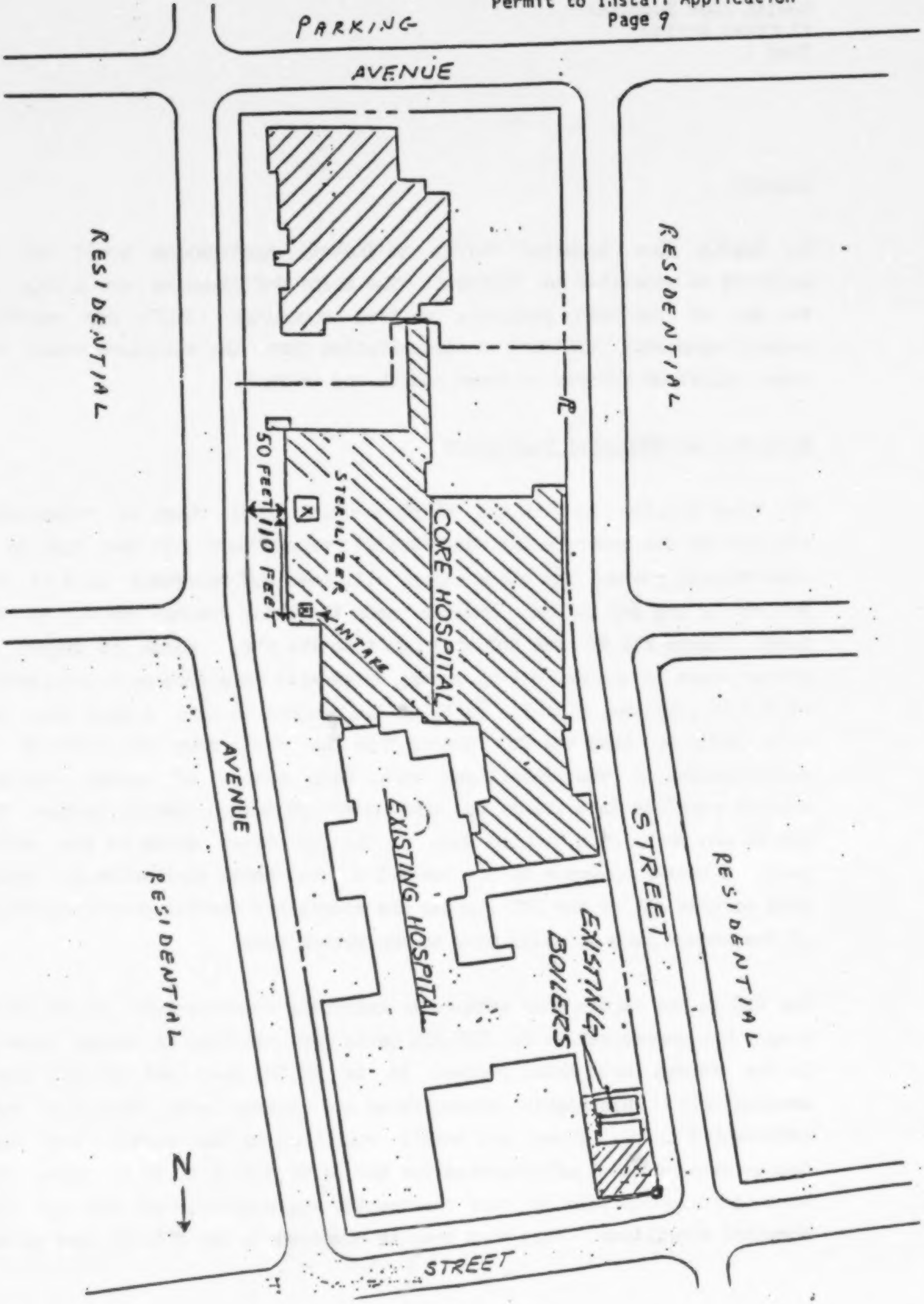
Note 3: When modeling the emissions as a building source, the area from the building to 25 feet past the sidewalk is considered to be in the building cavity. The maximum concentration will be found at all locations within this building cavity. In that this is a public hospital and the public and patients have access to the grounds of Health Spot as well as the sidewalk and the street, it is appropriate to look at concentrations and exposures of air pollutants at all points within the building cavity. In reality, when the emission comes from a single point (the discharge point of the vacuum pump), the concentration of air pollutants at some points within the building cavity may be even greater than the modeled values. Looking at on-property concentrations is different than the treatment of a normal industrial site, Typically, OSHA has jurisdiction over exposures to workers inside the fenced in property of the employer, and thus, air pollution regulatory agencies are not involved with exposures within this area.

Note 4: In terms of magnitude of emissions, the emissions from the vacuum pump represent the majority of the emissions. The emission of EtO which occurs when the sterilizer chamber door is opened, and the EtO remaining in the chamber exhausted, is not significant when compared to the amount of EtO exhausted by the vacuum pump. Therefore, for the purposes of the EPA conference, this smaller emission can be neglected. The same holds true for the EtO which comes off of the sterilized materials in the ventilated storage area. On an hourly basis, this emission is insignificant in comparison to the one hour emission of EtO from the vacuum pump. Of course, from an OSHA viewpoint of looking at EtO concentrations in the workplace, these emissions are of great concern. In that setting, a full review of these emissions is warranted.

Note 5: For the same reasoning that the public will be inside the hospital as visitors or patients, it is appropriate to look at the concentrations of air pollutants at the hospital air intakes. Such polluted air is subsequently distributed throughout the part of the building served by that particular air intake.

Additional Information

If additional information is required, please contact Mr. Jonathan L. Trout, Chief, Southeast Permit Unit, Air Quality Division, Michigan Department of Natural Resources, at (517) 373-7023.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Summary

The Health Spot Hospital Permit to Install Application would not be approved as submitted in Michigan. The major deficiencies are a lack of the use of the best available control technology (BACT) for volatile organic compounds (VOC) and a demonstration that the emissions would not cause injurious effects to human health and welfare.

Best Available Control Technology

The first problem is with the ethylene oxide (EtO) which is temporarily absorbed by the water in the water-sealed vacuum pump. In that this is a once-through system, the clean water will take approximately 15 % of the EtO out of the gas stream. However, once the water reaches the air in the drain, almost all of the EtO will go into the air. Given the amount of contact time in the neutral pH water, there will be almost no hydrolization of EtO to ethylene glycol. While it is prudent to have a hood over the floor drain so that the EtO coming from the drain does not build up in concentration in the sterilizer room, this method of worker exposure control does not lend itself to ambient air pollution control because the EtO is now much more diluted than in the gas stream going to the vacuum pump. A better approach is to install a total water recirculation vacuum pump so that all of the EtO leaving the sterilizer chamber during operation of the vacuum pump actually goes to the vacuum pump.

The EtO in the vacuum pump exhaust is extremely concentrated. In the first purge, the concentration is 203,238 parts per million, by volume (ppmv). In the second and third purges, it is 65,233 ppmv and 21,380 ppmv, respectively. This highly concentrated gas stream lends itself to very efficient control. There are acidic scrubbers on the market which have demonstrated control efficiencies for EtO of 99.9 % to 99.98 %. Also, the cost of these controls is very reasonable, approximately $15,000 for this hospital sterilizer. When that cost is compared to the $75,000 cost of the sterilizer, the percentage increase of the equipment with a control device is believed to be reasonable. Also, the operating cost is not expected to exceed $500 per year.

While the cost of control is approximately $15,000 to $20,000 per ton of EtO removed, we believe that this is a reasonable cost because of the carcinogen potential of EtO.

Environmental Acceptability

Based upon the modeling results of the uncontrolled emission of EtO which do not give any credit for the intermittent nature of the emissions, the calculated risk of additional cancer from EtO is 100 in one million (10^{-4}) at ground level and 500 in one million ($5*10^{-4}$) at the hospital air intake. This level of increased risk from the EtO sterilizer is not acceptable in Michigan.

However, after first using the application of best available control technology, the EtO emissions would be reduced to a level, both at ground level as well as the hospital intake, which would represent an increased cancer risk of approximately one in one million (10^{-6}) or less. This controlled level would be acceptable in Michigan.

Under the circumstance of a very low exhaust volume from the vacuum pump, there would be little difference in the ground level and air intake concentrations of EtO if the vacuum pump exhaust point were changed to the top of the building rather than the second floor. Therefore, with the addition of the acid scrubber, the planned exhaust location would not need to be changed.

Other Issues

While there is some small amount of EtO being emitted from the hood over the sterilizer and from the ventilated storage area, this amount is much smaller in magnitude than the amount emitted from the vacuum pump. In addition, the EtO concentration would be much smaller and would not lend itself to cost effective control. Therefore, we would not be concerned with these emission points, but instead would concentrate on the vacuum pump emission.

Michigan does not generally consider the intermittent nature of the emission of a carcinogenic compound. This position is taken because of the lack of scientific knowledge on the actual mechanism of the onset of cancer cells in the human body. Therefore, until a scientific basis is derived for understanding the effect or lack of effect of an intermittent exposure of a carcinogenic compound, we believe that the prudent course of action is to look at the worst case example of an emission being continuous.

Hospital Infectious Waste Incineration and Hospital Sterilization Workshops
May 1988
CASE II

Mercy Hospital
Permit to Install Application

General Description
Mercy Hospital, on the campus of Southern Michigan College, is proposing to install a new hospital incinerator capable of burning up to 1500 pounds per hour of pathological and infectious waste. The proposed unit will be a controlled air type incineration system with primary, secondary, and tertiary combustion chambers. It will be installed in the new Replacement Hospital Building (attachment 1).

Process Description
Waste will be brought to the incineration room as it is collected during the day. The waste will be double bagged and there will be no sorting of material. The incinerator will be preheated to a temperature of 1200 degrees F in the secondary chamber. The interlock system does not allow for waste to be fed into the unit until the 1200 degree F temperature is achieved. The waste will be charged into the primary chamber by a hopper/ram loader assembly. The primary chamber operates between 1500 to 1800 degrees F and at near stoichiometric air conditions. The flue gases pass through the secondary and tertiary chambers where additional air is added. If necessary, the natural gas-fired burners in these chambers provide additional heat to insure complete combustion. While waste is being burned, the gases will be at 1800 degrees F for a minimum of 1.0 second. The flue gases then pass through a two-pass, firetube waste heat boiler. The boiler will generate about 7500 pounds per hour of steam at 15 psig saturated. After exiting the boiler the gases are exhausted through a 227 foot stack, 15 feet above the building roof. The maximum operating schedule will be 16 hours per day, 5 days per week, 52 weeks per year.

Process Equipment Description

Fuel:	7,500,000 pounds/year waste from hospital & research activities
Capacity:	1500 pounds per hour of waste
Primary:	896 cf volume with maximum heat release of 14,250 BTU/cf/hr Normal operating temperature 1500-1800 degrees F
Secondary:	150 cf volume with 35-70% excess air added Normal operating temperature 1600-2000 degrees F
Tertiary:	Total 3808 cf volume with 35-70% excess air Normal operating temperature 1600-2000 degrees F
Exhaust:	6533 acfm at 450 degrees F, 6.0% CO2, and 6.14% Moisture 1899 dscfm at 12% CO2
Stack:	227 feet above ground level, 24 inch diameter
Building:	202 feet above ground level
Air Intake:	112 feet above ground level, 330 feet from stack (attach. 1)

Emissions and Impacts for Mercy Hospital Incinerator

Emissions	lbs/hr	ug/m3
Particulate	2.1	85805.8
Hydrogen Chloride	15.0	612898.5
Cadmium	3.5E-03	143.0
Chromium	8.4E-04	34.2
2378 TCDD Tox Equiv	2.4E-07	9.8E-03

The toxic equivalents were determined assuming the homologue distribution from Run #3 of the Royal Jubilee Hospital test and an equal occurence of isomers within each homologue as described by Hart (1982).

Maximum Ground Level Concentrations in ug/m3 (See Note 1)

Pollutant\Ave Time	Annual	24-Hour	8-Hour	1-Hour	10-Min
Particulate	0.25	2.29	4.93	14.39	28.78
Hydrogen Chloride	1.76	16.36	35.19	102.80	205.60
Cadmium	4.11E-04	3.82E-03	8.21E-03	2.40E-02	4.80E-02
Chromium	9.83E-05	9.12E-04	1.96E-03	5.73E-03	1.15E-02
2378 TCDD Tox Equiv	2.81E-08	2.61E-07	5.61E-07	1.64E-06	3.28E-06

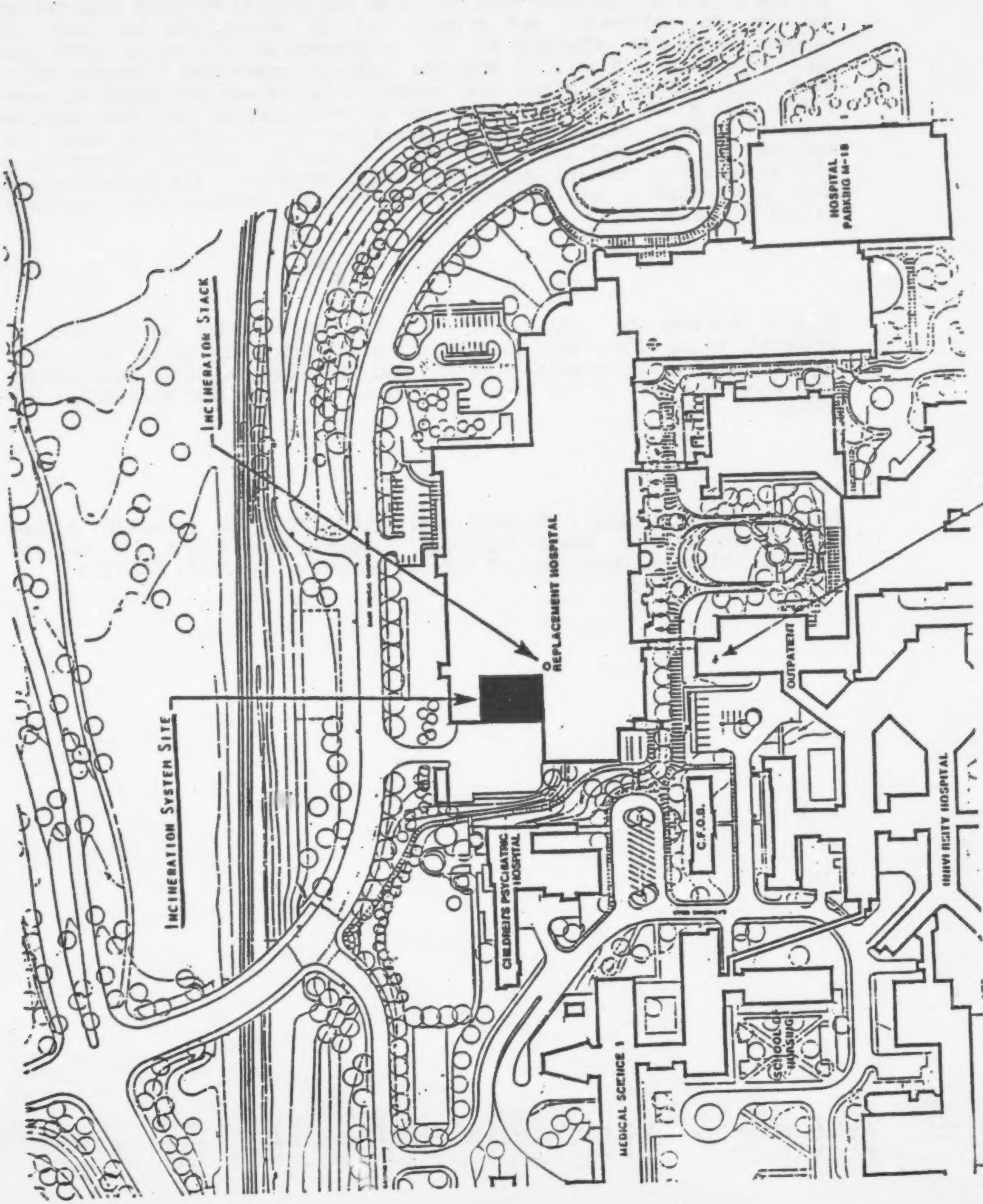
Maximum Air Intake Concentrations in ug/m3 (See Note 2)

Pollutant\Ave Time	Annual	24-Hour	8-Hour	1-Hour	10-Min
Particulate	0.46	7.57	20.72	64.47	129.03
Hydrogen Chloride	3.30	54.04	147.97	460.48	921.65
Cadmium	7.69E-04	1.26E-02	3.45E-02	0.11	0.22
Chromium	1.84E-04	3.01E-03	8.25E-03	2.57E-02	5.14E-02
2378 TCDD Tox Equiv	5.25E-08	8.61E-07	2.36E-06	7.34E-06	1.47E-05

Note 1 When modeling the emissions as a building source, the area within 1000 feet from the building (5 times the building height) is considered to be in the building cavity. The maximum concentration will be found at all locations within this building cavity. In that this is a public hospital and the public and patients have access to the grounds of Mercy Hospital as well as the sidewalks and streets, it is appropriate to look at concentrations and exposures of air pollutants at all points with the building cavity. In reality, when the emission comes from a single point such as an incinerator stack, the concentration of air pollutants at some points within the building cavity may be even greater than the modeled values. Looking at on-property concentrations is different than the treatment of a normal industrial site. Typically, OSHA has jurisdiction over exposures to workers inside the fenced property of the employer, and thus, air pollution regulatory agencies are not involved with exposures within this area.

Note 2 Because the public will be inside the hospital as visitors or patients, it is appropriate to look at the concentrations of air pollutants at the hospital air intakes. The polluted air is subsequently distributed throughout the part of the building that is served by that particular air intake

Additional Information If additional information is required, please contact Lynn Fiedler, Senior Engineer, Southeast Permit Unit, Air Quality Division, Michigan Department of Natural Resources, at (517) 373-7023.


INCINERATION SYSTEM SITE
INCINERATOR STACK
REPLACEMENT HOSPITAL
AIR INTAKE
OUTPATIENT
HOSPITAL PARKING M-18
CHILDREN'S PSYCHIATRIC HOSPITAL
C.F.O.B.
SCHOOL OF NURSING
MEDICAL SCIENCE I
UNIVERSITY HOSPITAL

Michigan Review
Mercy Hospital Permit Application

Summary
The Mercy Hospital Permit to Install Application, as submitted, would not be approved in Michigan. The major deficiency is the lack of a demonstration that the emissions from the incinerator would not cause injurious effects to human health and welfare. In addition, the applicant is not proposing to operate the equipment in a manner which will reduce emissions.

Environmental Acceptability
Based upon the modeling results shown in Table 1, the uncontrolled emissions of cadmium, chromium, and 2,3,7,8-TCDD toxic equivalents result in calculated risks of additional cancer of 1.5, 2.5 and 1 in one million at ground level and 3, 4.7, and 2 in one million at the air intakes, respectively. The Michigan Air Pollution Control Commission has previously accepted a risk of 1 in one million as being a level at which a carcinogen would not be considered to cause injurious effects to human health, and thus comply with the Michigan Rules. Therefore, the emission of cadmium, chromium and 2,3,7,8-TCDD toxic equivalents would not be considered to be environmentally acceptable. In addition, the emission of hydrogen chloride is at a level of concern. Hydrogen chloride is an irritant and the 1-hour averaging period has been deemed appropriate in Michigan. The proposed emission of hydrogen chloride is 1.5 times greater than the accepted level at ground level and 6.6 times greater at the air intake. Therefore, the emission of hydrogen chloride would not be considered to be environmentally acceptable.

Another item of concern is the combustion of waste at start-up. It is the belief of the Michigan Air Quality Division that the unit should maintain a temperature of at least 1800 F for a minimum of one second in the secondary combustion zone. The temperature must average on an hourly basis 1800 F and should not be less than 1600 at any time waste is being combusted. Any time the temperature monitor indicates a temperature approaching the minimum temperature of 1600 F, auxiliary fuel shall be added to the process. In the event that it is not possible to maintain 1600 F, all waste feed must be terminated immediately. This procedure is designed to insure complete combustion and thereby minimizing the emission of dioxins and furans.

Alternatives for the Applicant
There are alternatives for the permit applicant which include raising the stack or installing control equipment. Dispersion modeling studies were completed to determine the minimum stack height that the unit must be equipped with to comply with all of the air quality regulations and which is necessary to assure that excessive concentrations of toxic air contaminants will not be introduced into the hospital air intake system. The stack height necessary for the proposed unit was determined to be 375 feet. Because of structural constraints this alternative was not available to the permit applicant. The applicant has elected to install a venturi scrubber and packed tower absorber system to control the particulate (thereby controlling the cadmium and chromium) and acid gas emissions. In addition, larger natural gas burners will be installed to insure that the proper temperature is maintained when waste is combusted.

Michigan Parmit Review

Pollutant	Concentration (ug/m3) Ground Level	Air Intake	Accepted Ambient	Fraction of Accept Amb Ground Level	Air Intake
HCl (1-Hour Ave)	102.80	460.48	70	1.47	6.58
Cadmium (Annual)	4.11E-04	7.69E-04	2.67E-04	1.54	2.88
Chromium (Annual)	9.83E-05	1.84E-04	3.95E-05	2.49	4.65
2378 Tox Eq (Annual)	2.81E-08	5.25E-08	2.30E-08	1.22	2.28

Calculation for an intermittant emission of metals.
No credit given for other pollutants because of toxicity data basis.
Credit is given for 16 hrs vs. 24 hrs per day. (max credit to 8 hrs)
Credit is also given for 5 days per week vs. 7 days. (max credit to 5 days)

	Accepted based on 24 hrs 7 days	Accepted based on 16 hrs 5 days
Cadmium	5.60E-04	2.67E-04
Chromium	8.30E-05	3.95E-05

Hospital Infectious Waste Incineration
and Hospital Sterilization Workshops
May, 1988

CASE III.

This case study is based on three permits granted by the New York Department of Environmental Conservation, Division of Air Resources in Region 9, Buffalo, NY. Thanks to Henry Sandonato, P.E. of the NY DEC Region 9 Office who assisted in preparation of this case study.

EXAMPLE I.

Roswell Park Memorial Institute is a cancer research institute and hospital run by the New York State Health Department. Roswell Park is is surrounded by a residential neighborhood. (Map attached.) Example I. describes a Kellog Mann PB5 unit which was originally started up in June, 1968 and was permitted by the NY Department of Health. The unit now burns mainly Type 4 waste since Type 1 waste is burned at the newer Consumat unit also owned by Roswell Park (see Example II.)

Process Equipment Description

Fuel: Type 4 Waste
Capacity:

1. The original permit from 1968 allowed for 490 lb/h of Type 1 waste and 50 lb/h of Type 4 waste burned for 16 h/d and 260 d/y
2. The unit now burns 50 lb/h of type 1 and 4 waste for 8 h/d and 260 d/y

The stack height is 138 ft and is 5 feet above the nearest existing structure. The stack is 18 inches in diameter. The building housing the unit is 664 ft above mean sea level.

Burners and Exit Conditions

The primary chamber has one Incinomite H-1000-3 rated at 1 MBtu/h fired with natural gas.
The secondary chamber has two N-American 138B burners rated at 600,000 Btu/h fired with natural gas.
None of the burners have actuated temperature settings.

The unit's exit temperature is 275F. The exit velocity 22 f/s with an exit flow rate of 2300 acfm.

The incinerator must achieve a particulate emission rate of 0.50 lb/100 lb of refuse charged.

Special Conditions

The special conditions for the unit were for radioactive refuse and were contained in a letter dated 11/21/79. This letter lists allowable limits for approximately 20 radioactive isotopes expected in the waste; most are metal species. The letter is available from the NY DEC.

EXAMPLE II.

This Consumat C-325-PA Unit was built at Roswell Park for burning Type 1 waste replacing the Kellog unit permitted in 1968 (Example I.) The Consumat unit was permitted in 1986 under NY Air Guide #21, dated January 1987. The site is located next door to the existing Kellog unit.

Process Equipment Description

Fuel: The Unit is permitted for incinerating Type 1 and 4 waste.
Capacity:

1. The unit is permitted for 1600 lb/h of Type 1 waste at 8 h/d for 360 d/y.
2. The unit is permitted for 825 lb/h of Type 4 waste for 8 h/d and 360 d/y.

The stack height is 120 ft and is 20 feet above existing structures. The stack diameter is 42 inches. The building housing the unit is 580 ft above mean sea level.

Burners

The primary chamber has four Eclipse burners rated at 750,000 Btu/h fired with natural gas.
Secondary chamber has one Eclipse burner rated at 2.5 MBtu/h fired with natural gas.
Both burners have actuated temperature settings. The primary chamber is set for 1600F; the secondary chamber is set for 1800F.

The unit's exit temperature is 800-1000F. The exit velocity 22 f/s and the exit flow rate is 12,722 acfm.

The incinerator must achieve a particulate emission rate of 0.1 gr/dscf.

Special Permit Conditions (set by Air Guide #21)

1. The unit must be preheated to 1500 F before charging refuse.
2. The normal operating temperature will be a minimum of 1800F.
3. Ash will not contain more than 5% combustible matter.
4. A lock out device is required to prevent charging refuse below 1500F.
5. A dual temperature recorder will be included to record primary and secondary temperatures.
6. Operating instructions shall state that no red bag waste or type 4 waste be loaded until 1800F is reached.
7. The breeching shall contain provision for connection of future control equipment.
8. Ports for a smoke monitor must be included in the stack installation should monitoring equipment be required in the future.
9. Stack sampling ports are required.

EXAMPLE III.

Buffalo General Hospital is the largest private hospital in Buffalo. Buffalo General is expanding, adding additional beds and modernizing their facility. A new boiler house is being built. The amount of waste the hospital is generating is increasing at a time when their private haulers are restricting the waste they will take.

This permit involves the installation of a new solid waste incinerator at the Buffalo General Hospital which will result in the removal of an existing incinerator at the site and phasing out of operation an incinerator located at a nearby hospital. Start-up of the new unit is planned for August 1988. The Unit will be a Consumat Systems C-760-PA. The unit is under construction at a site just off the attached map.

The special permit conditions listed below note the ongoing development of New York regulations. These regulations may require retrofitting of the unit with additional control equipment. Buffalo General has agreed to meet any additional conditions established this year.

Process Equipment Description

Fuel: The unit is permitted for Type 1 and 4 waste.

Capacity:

1. For Type 1 waste: 2800 lb/h, 8 hr/d for 312 d/y
2. For Type 4 waste: 100 lb/h capacity with the expected amount charged to be 50 lb/h waste for 4 h/d and 312 d/y.

The stack height is 110 ft and is 80 feet above the nearest existing structure. The stack diameter is 56 inches. The building is located 660 ft above mean sea level.

Burners

The primary chamber has two North American 4422 burners each rated at one MBtu/h fired with natural gas.
The secondary chamber has two North American 4422 burners each rated at three MBtu/h fired with natural gas.
All burners are set for actuated temperature conditions. The primary chamber is set for 1600F; the secondary chamber is set for 1800F.

Exit Conditions and Emissions Limits

The unit's exit temperature is 700 F with an exit velocity of 30 f/s and an exit flow rate of 30,870 acfm.

TSP Emissions are permitted at 12.12 lb/hr (actual emissions) and annual emissions of 45,400 lb/y (23 tons/y.)

The incinerator must achieve a particulate emission rate of 0.1 gr/dscf.

Special Conditions

1. The unit must be able to heat to 1500 F before any refuse is charged.

2. The ash must not contain more than 5% combustible matter.

3. Stack testing will be required for combinations of Type 1 and Type 4 refuse unless an incinerator model is chosen on the NYS Incinerator List that is approved for Type 4 waste.

4. The unit must meet a particulate emission standard of 0.10 gr/dscf corrected to 12% CO2.

5. The secondary chamber must be designed to operate at 1800 F and a one-second retention time.

6. The loader must be fitted with interlocks to prevent charging waste until the secondary chamber exit temperature is at least 1600 F.

7. Space must be available should acid gas control be required in the future.

8. Pathological waste may only be burned with hospital waste if tested and found acceptable.

9. Continuous monitoring and recording of secondary chamber exit temperature is required.

10. The exit temperature must be at least 1600 F. and records must be submitted annually to show the exit temperature has been maintained.

11. Average opacity must be less than 10% during any consecutive six-minute period per hour or less than 20% is allowed, as determined by EPA Method 9.

12. The CO concentration must be sampled annually and results submitted to the DEC with a report of the condition and operation of the incinerator. This report shall be prepared by a qualified engineer and include a calibration of the instruments.

13. A stack test protocol must be submitted 90 days prior to startup of the unit. The unit must be stack tested for particulates, HCl, and CO concentration at startup and within 60 days after the protocol has been approved. DEC must be given the opportunity to observe the complete stack test.

These conditions are a result of Guidelines for Medical Care Waste Incineration issued by the Division of Air Resources in Albany. A copy of this information will be included in the Proceedings of the Workshops.

According to this guideline, additional air pollution controls will be required in the future after hearings are held during the Summer, 1988 and a new incinerator regulation is adopted.

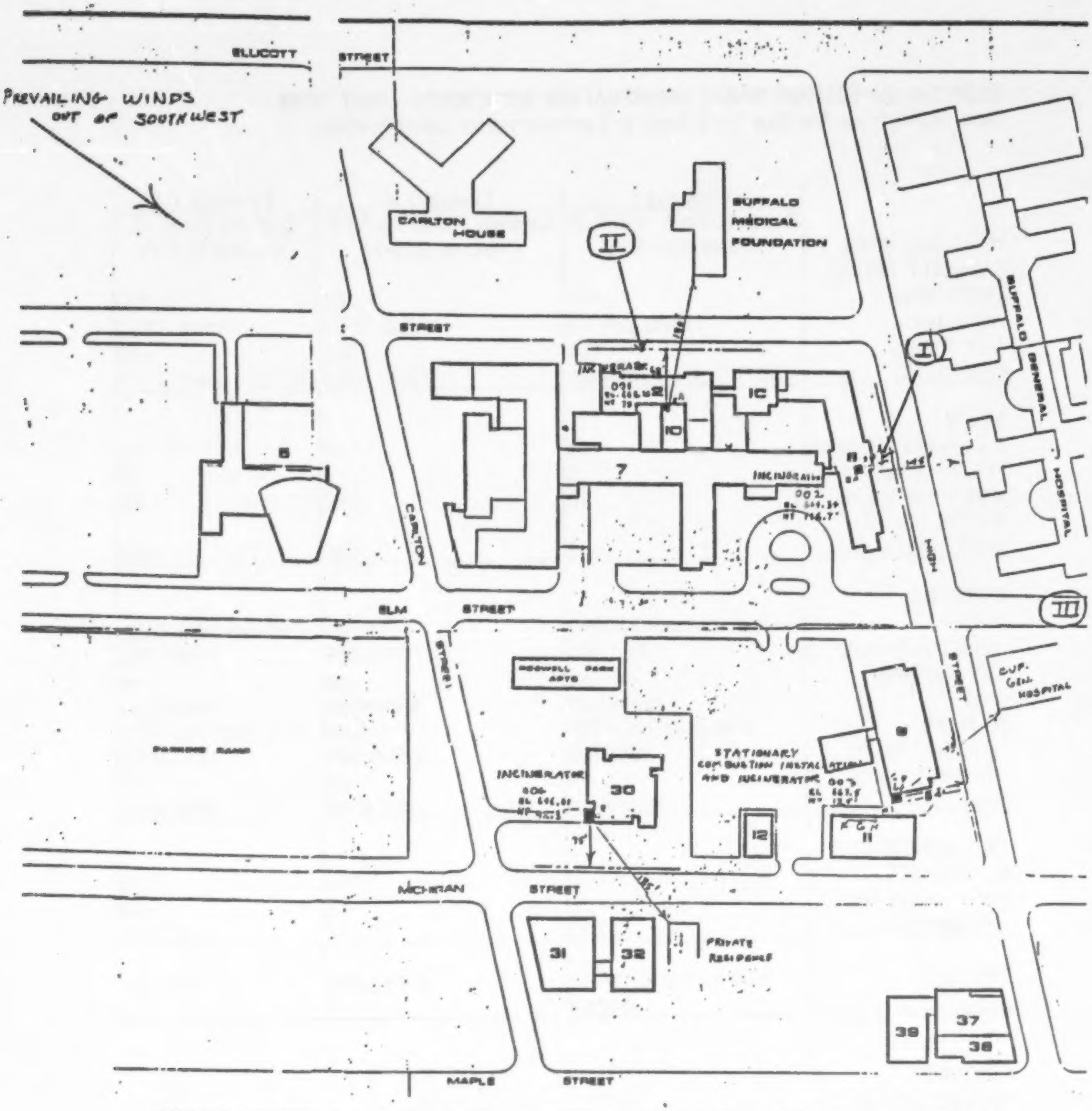
For further information on these permits please contact the NY DEC Region 9 office at 600 Delaware Avenue, Buffalo, NY 14202, (718) 847-4565. For further information on the New York regulations please contact Wally Sontag, NY DEC, 50 Wolf Road, Albany, NY 12233, (518) 457-2044.

NESCAUM
ny case st; 5/5/88

HOSPITAL INFECTIOUS WASTE INCINERATION WORKSHOPS - MAY 1988
Case Study from the New York Dept of Environmental Conservation

	Example I	Example II	Example III
	Roswell Park '68 Unit	**Roswell Park '86 Unit**	**Buffalo General**
MANUFACTURER	Kellog Mann PBS	Consumat 325-PA	Consumat 760-PA
CAPACITY (lb/h)			
Type 1 Waste	490	1,600	2,800
restrictions	16h/d, 260 d/y	8 h/d, 360 d	8 h/d, 312 d
Type 4 Waste	50	825	100
restrictions	50 lb/h; 8 h/d, 260 d/y	8 h/d, 360 d	50 lb/h; 4 h/d, 312 d
STACK			
stack height (f), above	138	120	110
existing structures	5	20	80
stack diameter (in)	18	42	56
building site (f)			
above mean sea level	664	580	660
BURNERS			
Primary	1- Incinomite H-1000-3	4-Eclipse	2-N. American 4422
capacity (Btu/h)	1,000,000	750,000	1,000,000
actuated temp	no	yes	yes
fuel	natural gas	natural gas	natural gas
Secondary	2-N. American 1388	1-Eclipse	2-N. American 4422
capacity (Btu/h)	600,000	2,500,000	3,000,000
actuated temp	no	yes	yes
fuel	natural gas	natural gas	natural gas
EXIT CONDITIONS			
exit temp (F)	275	1,800	700
exit volocity (f/s)	22	22	30
exit flow (acfm)	2,300	12,722	30,870
TSP limit	0.50 lb/100 lb refuse charged	0.10 g/dscf	0.10 g/dscf

NESCAUM
ny cases; 5/5/88



ELLICOTT STREET
PREVAILING WINDS OUT OF SOUTHWEST
CARLTON HOUSE
BUFFALO MEDICAL FOUNDATION
II
I
III
STREET
INCINERATOR
001
2
1C
10
7
6
INCINERATOR
002
HT 116.7'
8
CARLTON
BUFFALO GENERAL HOSPITAL
HIGH STREET
ELM STREET
STREET
ROSWELL PARK APTS
PARKING RAMP
STATIONARY COMBUSTION INSTALLATION AND INCINERATOR
003
INCINERATOR
004
30
9
12
BUF. GEN HOSPITAL
BGH 11
75'
135'
MICHIGAN STREET
31
32
PRIVATE RESIDENCE
37
38
39
MAPLE STREET

ROSWELL PARK MEMORIAL INSTITUTE
BUFFALO NEW YORK

JANUARY 1973

SESSION VII: DISCUSSION LEADERS REPORT ON THEIR CASE STUDY GROUPS (SAN FRANCISCO)

Report by Lynn Fiedler, Michigan DNR

Case Study #2

The group decided there were too few set points specified in the whole system. There was only one temperature set point and none for pressure. There was no documentation of how retention time and temperature were calculated. Retention time calculations should be the manufacturer's responsibility to provide, but the permitting agency should check the calculations. There should be more pollutants (especially CO) listed in the special conditions for the emission rates.

Looking at the air intakes is valid and many thought this was something that they might start doing. It is partly an OSHA problem, but still cannot be ignored.

Does the ash need to go to a special landfill? It is a solid waste problem, but perhaps air agencies should be involved to avoid just trading one problem for another.

Case Study #3

The group was confused about the temperatures. The three different units had three different exhaust temperatures specified in the special conditions, which should be more specific on where this temperature was located. In general, more details were needed. As the conditions are stated, they could not be defended in a public hearing.

The additive effects of toxics were not addressed. The three incinerators are close together and perhaps their combined impact should be analyzed.

Conditions 8 and 10 are confusing and need to be more specific.
Example I mentions radiation. The group was interested in state policies and practices on radiation. One state has detection limit requirements, i.e. commercial units can burn radioactives, but there must be no detection in the stack. This is only for commercial-size units because the cost is prohibitive for smaller units. Other states have no authority to regulate such emissions. Air agencies should consider who should handle the issue.

Model Rule

Existing units would shut down if this rule ever goes into effect.

The rule possibly should include PM_{10}. There should be more CEM required, e.g. for temperature and CO. Test methods, emissions limits, etc. should be better specified.

The group discussed the problem of everything being thrown in at once. Perhaps differential loadings, e.g. five regular bags and then a red bag, should be part of the operational procedures, although enforcement would be difficult.

Compliance testing should be conducted with "normal" rather than "worst case" waste. The group decided that testing should be comprehensive at startup, with reduced testing requirements each year thereafter to look at the toxics problem. There should be a size cut off — under a certain size, rules would take effect to deal with dispersion. Certain pathogens should not be tested, since their sources cannot be accounted for.

Report by Nancy Seidman, NESCAUM

Considering the downtime of an incinerator (10–20% of the time) due to acid gas buildup, degradation of materials, and molten glass congealing on grates, perhaps facilities need to think about what they are going to do with their waste if the incinerator is out of operation.

Regarding operators and training, were the operators in the case studies assigned to one job only or to diverse operation and maintenance responsibilities? Permit conditions should take into account whether the facility was going to have a dedicated operator. At larger facilities it might be realistic.

Regarding temperature conditions, what is the goal of a dual chambered type of incinerator? If it is pyrolysis in the primary chamber, the air-to-fuel ratio will be below stoichiometric. Then perhaps temperature is not the critical factor, and requiring temperature conditions in the primary chamber can be self-defeating. However, temperature conditions for the secondary chamber can be very important.

On testing and costs, stack testing at all facilities might force the use of regional facilities due to excessive costs to smaller facilities. Tests conducted under ideal conditions may provide at that moment in time an accurate measurement of what the incinerator is doing. Days later all the protocols may not apply. Overemphasis on stack testing may not be what agencies had in mind. But with CEM, we do not know exactly what we are asking for. Are they enforceable permit conditions? What will agencies do with all these monitoring data?

Why is arsenic on the list of metals? Where would it be in the waste feed? More generally, if certain materials could be kept from the waste stream, how would emissions change? HCl and lead levels may be affected. Dioxin may not be determined by chlorine that was in the PVC waste, but by multiple sources of chlorine in the waste stream. Separation of PVC probably would not eliminate dioxin as an emissions problem.

The group discussed waste shredding options, and whether an RDF approach for hospitals (as with wood waste) would have any benefits.

Chemotherapeutics are a RCRA waste and should not be going to an infectious waste incinerator. Drained IV bags which had chemotherapy drugs in them are acceptable.

The group held the opinion that hospitals' primary concern is patient care and that source separation may be low priority or unacceptable for them.

Recommendations for training are (1) that bioaccumulation should be discussed and addressed further and (2) staff should be trained who are reviewing the permits. Agencies are forced to rely upon data provided by the manufacturer. Perhaps applicants expect regulators to be design engineers and to review plans in greater detail. Many smaller agencies do not have adequately trained staff to review these permits.

Report by Wallace Sonntag, New York DEC

The case study permits needed more detail on design conditions, operating schedules, CEM information, description of BACT, test information, and cost figures. After the statement "multi-chamber" add "or equivalent alternative technology." Agencies should be prepared for advances in technology.

Requirements for permits vary from state to state. Permitting hospitals is similar to permitting toxics. Otherwise, there is not much difference from regulating any other stationary source.

Regarding specific pollutants, Cd, Cr, Pb, Hg, and As should be evaluated on a case-by-case basis. The group favored trying to design the system to preclude the formation of dioxins and furans and therefore avoid the need for testing. New York will hold hearings on this approach. Particulate levels of 0.015 gr/dscf corrected to 12% appear achievable. Most of the group would like to control HCl, but did not favor additional controls or limits on pathogens at present.

Most of the group agreed that waste management by source separation is not being practiced except in Ontario.

It is apparent that there is widespread ignorance among agency staff regarding hospital sterilization.

Report by Joann Held, New Jersey DEP

The group discussed how to handle intermittent operation for permitting purposes. If an analysis to determine control requirements assumes intermittent operation, then the permit should include conditions limiting operation to the same level. Most agencies assume operations occur 24 hours per day, 365 days a year, and do the analysis.

EtO sterilizers may require analysis of both acute and chronic health effects. The group was surprised at how long it takes to sterilize something. EtO comes out in a spike, a very different emission pattern from that of many of the combustion sources agencies are used to looking at where the source is continuous. Agencies may want to look at the annual average concentration for carcinogenesis, but at the spike for acute health effects.

Case #3

Only particulate levels were given. The group would ask for additional information on emissions of toxics and criteria pollutants.

When looking at the permit conditions for the third incinerator, the group would consider additional permit conditions. One should be a statement on what can or cannot be incinerated, and when. Add emission limits in tons per year, total operations per year, operating schedule, etc. If type 1 and type 4 wastes are to be burned together, testing should be required. CEM perhaps should be required on a case-by-case basis.

California and Maryland will have compliance requirements on existing sources.

Questions that were brought up by the group include: (1) Is PVC the only type of plastic that produces HCl emissions? (2) How are hospitals disposing of radioactive waste? (3) How are agencies addressing PM_{10} emissions?

Suggestions that the group made include: (1) having size classifications, (2) testing only larger facilities annually while reducing the frequency or types of pollutants tested for by the smaller facilities, and (3) given the context of unit size and what types of emissions are associated with the 0.015 gr/dscf particulate standard, this standard does not seem to be a reasonable requirement for every agency.

SESSION VII: DISCUSSION LEADERS REPORT ON THEIR CASE STUDY GROUPS (BALTIMORE)

Report by Chris James, Rhode Island DEM

The group considered the model rule and two questions:
(1) Should requirements be less stringent for existing units?
(2) Should there be a size cutoff below which small units are exempt from requirements?

The group agreed on the model rule but differed on specific approaches. The consensus was that control equipment is not feasible for small units. Some favored shutting down small incinerators in favor of regional facilities, as small units tend to have poor combustion control and to be located in areas with high population exposure. Others favored phasing out existing units, but then alternative disposal must be provided, lest illegal disposal increase as with hazardous waste.

Illinois, in an apparent loophole in its regulations, would allow a proposed mobile incinerator to travel a circuit, parking one day per week at each hospital.

Ohio reported no problems siting commercial incinerators.

California suggested considering a lower size cutoff for existing units based on risk. If the risk is above a threshold, they would be required to install controls or shut down. LAER is recommended for new units. California is also considering spore testing to determine whether pathogens survive.

California has found that while hospital administrators are willing to spend large sums for medical hardware (CAT scanners, etc.) they balk at similar expenses to protect public health with incinerator controls.

New York stated that state or federal grants exist for hospital incinerators, and should be considered as a way to encourage replacement of old units.

One member cautioned that in calculating retention time the maximum BTU input should be used, not the average input. Another stated that present technology incinerators are not the whole solution. Alternatives could include 3 or 4 stage incinerators, fluidized bed combustion, or non-incinerator options.

Report by Randal Telesz, Michigan DNR

Model Rule

The group variously interpreted the model rule as implying Federal BACT, state-of-the-art controls, or requiring that a standard be met. No member advocated a state-based BACT rule.

Temperature: The majority selected 1800°, with one state each choosing 1600° and 1500°. Rather than having a single temperature regulation, temperature requirements should be matched to the equipment (e.g. adjustable for fluidized bed units, and 1800° for controlled air units).

Residence Time: Most specified 1 second, but three specified 2 seconds. If a proposed facility applied under a 1 second rule but wanted to burn toxics, the group might require the design to be expandable to increase residence time.

Design: The criterion should be good combustion with turbulence.

Pollutants: Metals should be subject to review. Dioxins should be reviewed case-by-case as needed. A reasonable CO limit would be 100 ppm. Some incinerators would not be able to attain 50 ppm if required. No state has considered PM_{10}. For TSP, three states require 0.08 gr/dscf at 12% CO_2, two states had 0.03-0.04, one had 0.02, and all agreed that 0.015 is too strict.

Case Study #2

The group decided that enough information had been provided to do the review. Special conditions to be imposed included CEM for CO, and possibly CO_2 or O_2 or both. If a scrubber is installed, pH monitoring would be helpful. If CEM for HCl were available at low cost, it should be required, especially on units of over 500 lb/hr. Given the choice between CEM, and sampling once per year for HCl, the group chose CEM.

The group specified that charging rates must be controlled to avoid temperature peaks, and that the unit should be preheated to operating temperature before charging. If minimum temperatures are not maintained, problems with bottom ash may result. Ash should be tested for burnables.

In seeking precedents, most states compare hospital waste with municipal waste, but one state used hazardous waste for comparison. EPA should provide guidance to help state agencies lobby their legislatures for authority to regulate hospital waste.

For existing units, more stringent regulation is one to two years away in most states. The majority are now considering either ambient concentration limits or control requirements. Small incinerators will probably be subject to the same regulations but will be phased out if they cannot comply by a cutoff date.

Report by David Painter, EPA OAQPS

Model Rule

Temperature: The group favored 2 seconds (over 1 second) as a safety factor, absent empirical data on feed variability and pathogen survival. Interlocks should be required so that waste cannot be charged until the primary chamber temperature reaches 1500° and the secondary reaches 1800°.

Size Cutoff: The group decided that a dry scrubber and baghouse should be required if HCl emissions exceed 4 lb/hr. If the plastics content of waste increases, the cutoff should be decreased because of potential PCDD emissions. The group favored scrubbers in all cases but recognized questions of practicality, e.g. should scrubbers be required for a unit operating 6 hr/day, 2 days/wk, as opposed to an identical unit operated continuously.

Monitoring: Temperature and CO monitoring should be required. An opacity monitoring requirement in the absence of scrubbers would be useful as an incentive to install scrubbers. Opacity monitoring would also be useful for units which are operated at night. The agency should also impose record-keeping requirements.

Case Study #3

Unit 1: The height of the stack above the building is too low; therefore its impact should be modeled. The stack exit temperature is also too low, but the information is vague. More data are needed from the applicant.

Unit 2: Modeling is also needed for this stub stack. More information is needed on burner modulation. An annual stack test and provision and space for future air pollution controls would be required.

Unit 3: This stack should also be modeled as it is clustered with the other two. The stack exit velocity of 30 fps should be doubled because a scrubber if required would decrease the stack exit temperature and reduce dispersion.

CEM would be required for CO. The opacity requirement would be tightened from 10% to perhaps 5%. The group criticized as vague the proposed 5% limit on combustibles in ash. Questions that would have to be answered include the details of the test protocol, how frequently to test, and how to account for variations in the ash.

The group also questioned item #3 concerning stack testing if combinations of types 1 and 4 waste are burned, because this provision could be used as a loophole to avoid stack testing. Regular testing of both the front and back halves should be required.

Report by Wallace Sonntag, New York DEC

Model Rule: The group generally agreed with the requirement for 2 seconds residence time at 1800°.

Design: Regulations for multichamber incinerators should be written to require good combustion turbulence, but should allow alternatives for innovative technology. Stack height increases should be allowed for noncarcinogens only, i.e for pollutants which can be rendered harmless by dilution.

Testing: The group compared the case study with New York DEC requirements for testing TSP and HCl. More than half the group disagreed with the case study provision for testing only particulates and CO. A 100 ppm hourly average for CO was thought to be acceptable. Stack testing might be done annually, but definitely should be done upon startup.

Controls: For particulates control, the group was comfortable only with a baghouse, but this may be unacceptable on small units. Acid gas scrubbing is needed, at a minimum, on the large units. The benefit of acid gas scrubbers is flue gas cooling, which condenses metals and semivolatiles. No additional controls for pathogens would be needed.

The issue of containers for sharps is really a solid waste problem, not an air quality problem.

Monitoring: The group agreed with the recommendation for monitoring primary and secondary temperatures, opacity, CO, and O_2. Opacity monitoring might not be needed with particulate control. However, an opacity monitor would be useful in the event of an incinerator malfunction. CEM reports should be provided quarterly to the agency.

Public Comment: A public hearing should be held. Most agencies provided at least one notice of agency action, and Ohio has up to three.

Small Sources: The group favored a lenient policy of not shutting them down "if public health is not endangered."

OPEN DISCUSSION OF CASE STUDIES

SUMMARY OF DISCUSSION (SAN FRANCISCO)

•

Q: In response to Ms. Seidman's comment that the hospital's first responsibility is to its patient: under most state laws, a publicly held corporation's first responsibility is to its shareholders to produce a profit.

A: (Unidentified speaker) A hospital's responsibility starts with the administrators and often filters down to the staff. The problems are in the designs of these incinerators, not the people who work there.

Q: There is a plastic that has 2-3% chloride in it, compared to about the 40% chloride in PVCs.

A: (G. Aburn, MD DOH) Expect to see chlorine in CFC styrofoam.

Q: Burning radioactive wastes does not destroy them. Burning may allow reduction of the volume of waste contaminated with radiation, which would reduce the transportation and disposal costs.

A: (M. Tierney, WI DNR) On radioactive wastes, Wisconsin defers to the Nuclear Regulatory Commission to permit the facilities. Hospitals do separate radioactives and deposit them into low-level waste depositories.

(W. Sonntag, NY DEC) New York hospitals have definite handling and disposal methods for low-level radioactive waste. There are well regulated procedures. If material is very "hot" it is sent to special facilities.

(N. Seidman, NESCAUM) Some facilities have a geiger counter. If trucks arriving for disposal of their wastes have high enough readings, they are turned away from the facility.

(S. Shuler, Ecolaire Corp.) On low-level radioactive waste, the information on permitting, regulating, and incinerating of radioactive waste is extensive. Contact Charlotte Baker with the University of California at Irvine. Ms. Baker held an international conference on incineration of hazardous waste, low-level radioactive waste and mixed waste.

Q: On ash handling: in Washington ash is tested and potentially goes to a hazardous waste facility.

Q: On the 0.015 gr/dscf particulate standard, does the cost involved really justify the extra risk reduction?

A: (D. Campbell, Env. Can.) As a result of BACT requirements, an incinerator with scrubber achieves 0.01-0.02 gr/dscf.

The 0.015 gr/dscf particulate level removes most of the metals, dioxin, and furans from the waste stream. That is probably why it is set so low.

(G. Shiroma, CARB) CARB is collecting information on the control measures for hospital waste incineration, the associated costs, and what the reduced risk is estimated to be for California facilities.

OPEN DISCUSSION OF CASE STUDIES

SUMMARY OF DISCUSSION (BALTIMORE)

Q: Short stacks should not automatically be allowed if there are no carcinogenic emissions. Applicants often submit proposed short stacks because they have not given sufficient thought to stack height. A criterion is needed for stack height, perhaps analogous to EPA's rule of allowing a high stack as long as it is lower than the GEP height.

Q: Regarding the scrubber requirement for units emitting over 4 lb/hr, why not use a venturi scrubber rather than a dry scrubber plus baghouse?

A: (D. Painter, EPA) A venturi scrubber is an option. The tradeoff between the baghouse and the venturi scrubber is one of pressure drop versus cost. The biggest problem is finding air pollution controls for units of under 10,000 cfm. The real issue is grain loading not flow rate.

Q: How frequently should stack testing be conducted?

A: (W. O'Sullivan, NJ DEP) One approach is to test comprehensively at startup, then test at intervals (maybe annually) in a more focused way to minimize costs. Annual tests might be for particulates, HCl, and CO.

Q: In comparing venturi scrubbers to packed scrubbers, the latter control metals more effectively. But there is a risk of Cd contamination with the water discharge from any scrubber.

A: (W. O'Sullivan, NJ DEP) A similar problem arose in New Jersey with Hg in the water. The scrubber effluent required treatment before it could be discharged to the municipal sewer system. High levels of Hg remained in the sludge.

(J. Lauber, NY DEC) The hazardous materials issue is analogous to that encountered with municipal solid waste. Metals concentrate in the fly ash. In dry scrubbers a mixture of lime and fly ash is nonhazardous since the lime and ash form a cement-like matrix which traps the metals. So dry scrubbers are a favorable alternative.

Q: A previous presentation reported test results showing ash to be hazardous. Did that system have lime injection?

A: (Unidentified speaker, NY DEC) No. It was a 2000 lb/day existing incinerator with a baghouse only. The fly ash tested well above the cutoff for EP toxicity. At a 115 tons/day municipal solid waste incinerator with dry lime injection, of 12 extraction tests of ash, two were over the limit.

The New York DEC solid waste staff has discussed liming of hazardous ash so that it will pass the EP toxicity test. However, there is only a narrow range of pH in which leaching is inhibited, so this method must be used only with care.

Q: The energy grants mentioned previously are for heat recovery systems, but heat recovery may increase PCDD emissions.

A: (J. Lauber, NY DEC) Anything that decreases the temperature (heat recovery usually implies 400°-450°) will remove condensibles. Theoretical approaches are not well developed, but empirically any temperature decrease (based on experience with scrubbers) will provide control.

Q: In a scrubber there is a "rapid quench" effect, whereas in a heat recovery boiler there is a slow transition through the optimum temperature for PCDD formation.

A: (J. Lauber, NY DEC) The evidence is that dioxins exist in two phases — gas and particle. When the temperature drops in the scrubber the vapor condenses on the particles, and then the baghouse removes the particles. So the "middle" doesn't matter if the "back end" is controlled. Good combustion plus good controls will give good results.

Q: What should be done to ensure adequate turbulence in the combustion chambers?

A: (C. James, RI DEM) Some jurisdictions (e.g. Ontario) have guidelines on Reynolds numbers.

(W. Sonntag, NY DEC) One researcher suggests a Reynolds number of 10,000 for adequate turbulence.

Q: Sludge must not be allowed to build up in the scrubber.

A: (W. O'Sullivan, NJ DEP) A specific gravity limit can be used to control the scrubber bleed to minimize sludge buildup.

Q: In a wet scrubber one can test the scrubbing water for dioxins. Pilot tests show that if combustion is good there are no dioxins in the water; therefore, scrubber water can be sampled to check incinerator operation. If breakthrough occurs in the scrubber, dioxins should appear in the water.

Q: Hospital directors in Michigan have said that they do not have a mechanism to hear the concerns of their administrators responsible for waste disposal. Such a mechanism would make a big contribution toward solving hospital waste problems.

Q: How does one approach the idea of "good" turbulence?

A: (D. Painter, EPA) For municipal waste combustion one derives a CO profile of the combustion zone, but this is difficult and costly. Also, it may not be valid given the variability of the waste. A previous speaker had recommended measuring fixed carbon in the ash. If the result is less than the manufacturer's guaranteed level then combustion is assumed to be good. However, there are still unresolved issues of how to sample and analyze ash to ascertain the fixed carbon content.

Q: Have any regulations on hospital waste incineration been promulgated in the last year or two?

A: (Unidentified speaker) Pennsylvania and Philadelphia have. Some other jurisdictions have guidelines. New York has a proposed regulation and expects to have the final regulation in September, 1988.

Q: What guidelines are available for new incinerators?

A: (K. Shannon, Ohio EPA) The Ohio EPA uses the following guidelines.
Particulates: BAT (Best Available Technology, analogous to RACT) is 1 lb/100 lb charged.
HCl: 4 lb/hr
Temperature: 1600° in secondary chamber. No standard for residence time.
Units over 400 lb/hr capacity must have mechanical feed and a lockout that prevents waste feed if the temperature in the secondary chamber is less than 1600°.

Battelle Memorial Institute is evaluating BAT for Ohio. Battelle will make recommendations on temperature, residence time, need for air pollution controls (for acid gas and perhaps NO_x) and dioxin standards, and regulation of existing incinerators as well as new facilities.

(W. O'Sullivan, NJ DEP) Tennessee also has regulations.

Q: What information is available on particle size distribution?

A: (W. Sonntag, NY DEC) According to Anderson 2000, the particles are very small, e.g. titanium dioxide particles tested were all smaller than 2 microns. Sampling is difficult.

(R. Telesz, MI DNR) Michigan is considering the particle size issue.

(J. Lauber, NY DEC) At a hospital waste incineration conference in Washington, DC, a paper discussed airflow control to minimize the transport of large carbon particles into the secondary chamber. Too high a temperature in the primary chamber causes particles to be carried too far. Incinerators should be designed to keep particles in the primary chamber since they are harder to burn than gases.

(W. O'Sullivan, NJ DEP) Tests on a controlled air incinerator in New Jersey found that all particulates were under 10 microns and a "considerable amount" were under 2 microns, so one can consider total particulates to be fines.

(R. Waterfall, NY DEC) As a practical matter, old impactors for particulate sampling are obsolete. New equipment uses gas recycling for isokinetic sampling, but requires impractical port sizes (e.g. 6 inch diameter port in a 20 inch duct). A new method under study involves recycling of gas to maintain a steady flow. The nozzle velocity can be varied according to duct velocity, and a multicyclone is used for sampling.

Q: What information is available on pathogens in ash?

A: (J. Lauber, NY DEC) EPA should survey European standards on hospital waste to gain insight on pathogen survival.

Q: Is ash disposal considered in the permit review process?

A: (W. O'Sullivan, NJ DEP) Not by the air agency in New Jersey. The solid waste agency has its own regulations.

(Unidentified speaker) In Philadelphia, the proponent must apply for separate air and solid waste permits, and the two agencies must agree on ash disposal.

(R. Telesz, MI DNR) In Michigan, when air permits are issued, the solid waste agency requires a test and then acts on the results.

Q: Perhaps ash should be treated as hazardous but should not be so designated. Call it a "special waste" instead.

A: (D. Painter, EPA) European agencies are doing something like this with ash from municipal waste combustion. They are considering burying ash in caverns. However, as with any landfill, this option still involves potential ash emissions to the atmosphere during transportation or at the disposal site. Designation of waste may determine which landfill is used, but the important issue is the overall impacts of disposal, not necessarily the choice of landfill.

Q: Which agencies conduct a comprehensive risk assessment for air or multimedia impacts?

A: (W. O'Sullivan, NJ DEP) [By a show of hands at the session] 14 out of 45 do risk assessment for air, and a few do multimedia/multipathway risk assessments. Some of the latter few agencies do such studies only for certain facilities.

Q: At the Commerce facility, ash collected by the dry scrubber/baghouse was left in an open shed. This raises the issue of particulate emissions when the ash dries out. According to manufacturers, chlorine salts could be formed at units with wet scrubbers, and emissions are possible when the ash dries. What emission information is available?

A: (W. O'Sullivan, NJ DEP) Studies have found salts from the scrubber to be a large proportion of the particulate catch unless there is a good demister.

In Philadelphia, ash from ash piles blew into a neighborhood. The ash failed the EP toxicity test and the incinerator was shut down.

Q: Incineration of trash just concentrates the metals, and they still go to the landfill. What are the alternatives?

A: (J. Lauber, NY DEC) The New York State University at Stony Brook has experimented with municipal waste ash from the Westchester facility. With 15% Portland cement it forms a cinder block. They are building reefs with the blocks. After one year in a marine environment the material does not leach. Reports are available.

Q: The process emissions from manufacturing cinder blocks are a concern.

Q: Are any states not using a technology-based (BACT or LAER type) review for new hospital waste incinerators?

A: (R. Morrison, USEPA) [Results by a show of hands in the session:]
Letter-of-the-regulation emission limit only: 8 states.
BACT/State-of-the-art review: 22 states.

Therefore, there is still a need for Federal guidelines.

SESSION VIII

HOSPITAL STERILIZERS - NATURE OF THE PROBLEM AND STATE PERMITTING EXPERIENCE

OSHA REGULATIONS REGARDING ETHYLENE OXIDE

Elizabeth Gross
Dana-Farber Cancer Institute

Presented at:

HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP

Golden Gateway Holiday Inn
San Francisco, CA
May 10-12, 1988

I. OSHA - 1910.1047 Ethylene Oxide - C_2H_4O

PEL - 1 ppm, taken as an 8-hour, time weighted average (TWA)

ACTION LEVEL - 0.5 ppm   **STEL**: 5 ppm, 15 min. TWA

EXPOSURE MONITORING -

Gen. - Breathing zone samples, representative of employee's exposure.
Full shift measurements.
Each job classification.

Exposure Measurements

- Date
- Operation involved
- Sampling and analytical methods
- Number, duration and results of samples
- Type of protective devices
- Name, social security number and exposure of employee
- Maintain thirty years

Training Program - Initially and at least Annually

- OSHA Standards
- Operations where EtO is present
- Medical surveillance program
- Methods to be used to detect presence or release of EtO (i.e. monitoring devices)
- Physical and health hazards of EtO
- Methods of protection
  - Policy
  - Procedure book
  - Emergency plan
  - Protective equipment
  - Labeling system

Limited Use of Respirators

- Where engineering controls are unfeasible such as:
  1. During interval necessary to install or implement engineering controls.
  2. Maintenance/repair activities.
  3. Emergencies.
- Must be provided by employer

- Must follow OSHA 29 CFR 1910.134 requirements for respirator program which includes:

  Selection, fit, use, cleaning and maintenance of respirators.

Medical Surveillance

- Performed by or under supervision of a licensed physician.
- Offered upon initial assignment and yearly thereafter where EtO known (likely to be).

  ≥ 0.5 ppm

  at least 30 days/year

- Offered in emergency situation and to those who believe they have signs of overexposure or are concerned about the reproductive effects of EtO.
- Required elements of program
  - Medical/work history
  - Comprehensive physical
  - Complete blood count

Communication of EtO Hazards to Employees

- Signs for regulated areas must state:

DANGER
ETHYLENE OXIDE
CANCER HAZARD AND REPRODUCTIVE HAZARD
AUTHORIZED PERSONNEL ONLY

RESPIRATORS AND PROTECTIVE CLOTHING MAY BE
REQUIRED TO BE WORN IN THIS AREA

- Temporary Regulated Areas must also be posted.
- Containers of EtO must be labeled:

CAUTION
CONTAINS ETHYLENE OXIDE
CANCER AND REPRODUCTIVE HAZARD

Precautions for Safe Use and Handling and Storage

A. Highly flammable

Vapors → explosive mixtures in air

- Store in cool, well-ventilated i.e., safety cabinet
- Remove all sources of ignition
- Remember clothing if wet with EtO → flammable
- No food or beverages or smoking
- Fire extinguishers, showers, access

USE OF ETHYLENE OXIDE BY HOSPITAL STERILIZERS IN THE SAN FRANCISCO BAY AREA

Tim Smith
Bay Area Air Quality Management District

Presented at:

HOSPITAL INFECTIOUS WASTE/INCINERATION AND HOSPITAL STERILIZATION WORKSHOP

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USE OF ETHYLENE OXIDE BY HOSPITAL STERILIZERS IN THE SAN FRANCISCO BAY AREA

Tim Smith
Eugene Willner

Bay Area Air Quality Mgt. District
May 1988

THREE PART DISCUSSION

(1) Results of BAAQMD Survey of Hospitals

(2) Types of Sterilizers in Use in BAAQMD

(3) Overview of Issues Involved in Evaluating New and Existing Sterilizers

HOSPITAL STERILIZER SURVEY

- Hospitals are much smaller EtO users than commercial sterilizers (medical equipment, spices, etc.)
- Little data on actual usage
- Goal of Survey: Evaluate priority of hospital sterilizers relative to other categories in the BAAQMD Toxic Pollutant Inventory

Scope of Survey

- Approximately 100 hospitals in the Bay Area
- Survey sent to each hospital requesting

  (1) Usage of EtO or 12/88

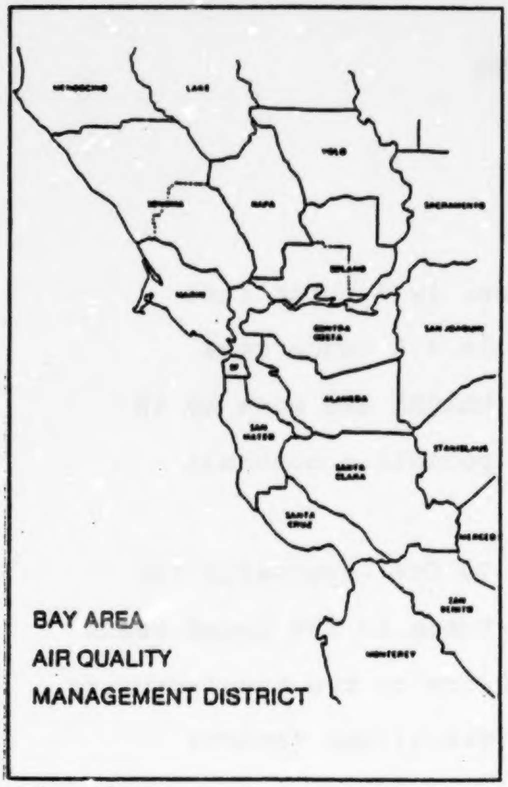
  (2) Make/model, chamber volume

  (3) Nature of sterilization cycle

  (4) Area there any emission controls?

Good Survey Response

- About 90% returned the survey
  - 77 had sterilizers
  - 13 did not
  - 10 have not responded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CONTRA COSTA
SAN JOAQUIN
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ALAMEDA
SAN MATEO
STANISLAUS
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SANTA CRUZ
MERCED
SAN BENITO
MONTEREY
BAY AREA
AIR QUALITY
MANAGEMENT DISTRICT

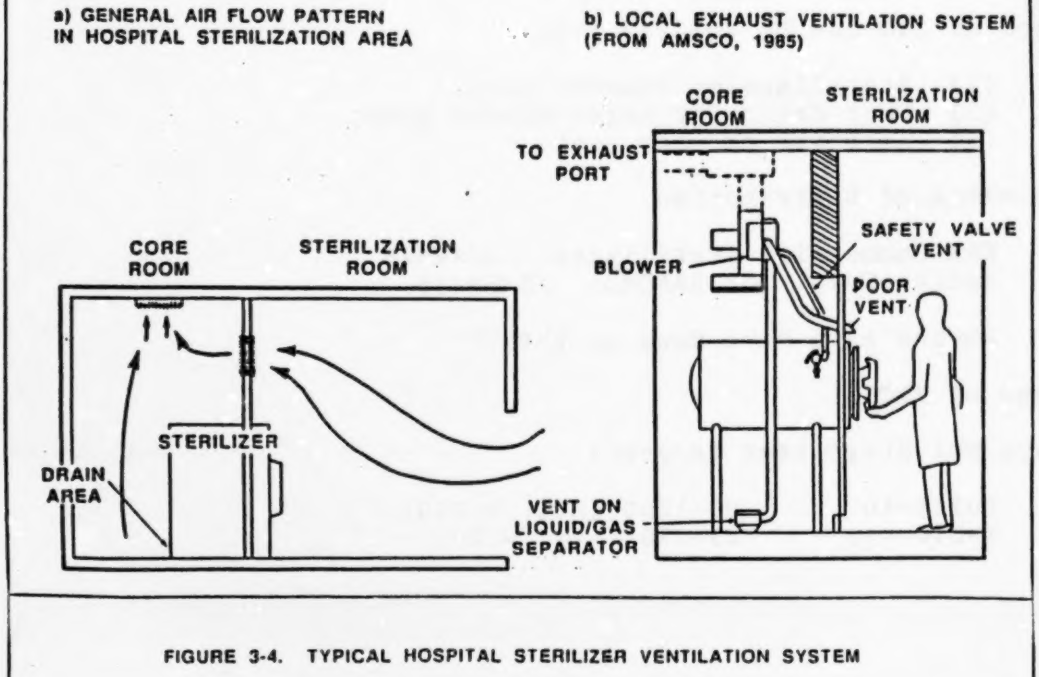
a) GENERAL AIR FLOW PATTERN IN HOSPITAL STERILIZATION AREA
CORE ROOM
STERILIZATION ROOM
STERILIZER
DRAIN AREA
b) LOCAL EXHAUST VENTILATION SYSTEM (FROM AMSCO, 1985)
CORE ROOM
STERILIZATION ROOM
TO EXHAUST PORT
BLOWER
SAFETY VALVE VENT
DOOR VENT
VENT ON LIQUID/GAS SEPARATOR

FIGURE 3-4. TYPICAL HOSPITAL STERILIZER VENTILATION SYSTEM

TYPES OF STERILIZERS

- Table-Top
- Built-In

Table-Top

- Sizes -- Typical is 4 cubic feet
- Uses 100% EtO in 4.5 ounce cans
- Almost all in BAAQMD are made by 3M
- None have air pollution controls

Built-In

- Sizes -- 8 to 70 ft^3 (typically 30)
- Use 12/88 EtO/Freon in 135 pound tanks
- Most in BAAQMD are by two manufacturers

  (1) American Sterilizer (AMSCO)
  (2) Castle

- None have air pollution controls

Distribution of Emissions

Usage of EtO can be emitted from:

(1) Sterilization chamber vent
(2) Vent drain (if water-sealed pump)
(3) Aeration chamber vent

Estimates of Distribution

EPA/Commercial Sterilizers: 50/45/5
Radian Corp. for BAAQMD: 25/50/25

Anyone else have data on this??

Usage of EtO

Usage per Sterilizer (#/year)

Built-in	80-1200 (Avg. = 360)
Table-top	23-270 (Avg. = 70)

Usage per Sterilizer (#/day)

Built-in	0.2-3.3 (Avg. = 1.0)
Table-top	0.06-0.7 (Avg. = 0.2)

Pounds per Bed = ???????????????

Ambient Concentrations Near Sterilizers

* SCAQMD: 9 Parts per Trillion Average in South Coast Basin

* SCAQMD: 80 ug/m^3 (140 ppt) Ann. Avg. for a 1/2 Pound per Day Unit

* BAAQMD: PTPLU Run: 300 Parts per Trillion (Annual Average) for a 1 Pound/Day Unit

* Emission Occur Over Minutes -- Short-term peaks are much higher than annual average

Cancer Potency for EtO

$= 100 \times 10^{-6}$ at one ug/m^3

$= 180 \times 10^{-6}$ at one ppb

$= 0.18 \times 10^{-6}$ at one ppt

Potent Carcinogen

* By Comparison

-- PERC, Methylene Chloride, TCE, are $0.5 - 5 \times 10^{-6}$ at one ug/m^3

-- California DHS Benzene Value $= 53 \times 10^{-6}$

Risks

* Even small table-top models probably exceed one in million

* Typical models probably exceed ten in a million without controls

NEW SOURCE ISSUES

1. Do health risks warrant controls?
2. What control efficiency can be achieved? With acid scrubbers? With catalytic oxidation?
3. What are the costs of control relative to the cost of the sterilizer itself?

EXISTING SOURCE ISSUES

1. Do the health risks warrant controls? Should more lenient standard apply?

2. Retrofit Issues

   (1) Degree of variation in flow, conc.
   (2) Capture efficiency
   (3) Space for control equipment
   (4) Cost to retrofit recirculating pumps
   (5) Overall disruption to the industry

ST. LUKE'S HOSPITAL
ETHYLENE OXIDE STERILIZER
A CASE STUDY

Danita Brandt
Michigan Department of Natural Resources
Air Quality Division

Presented at:

**HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP**

Golden Gateway Holiday Inn
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MICHIGAN DNR
AIR QUALITY DIVISION

Danita Brandt

ST. LUKE'S HOSPITAL ETHYLENE OXIDE STERILIZER A CASE STUDY

PERMIT APPLICATION

- Submitted Feb. 2, 1987
- EtO Sterilizer and Aerator

PROPOSED PROCESS

- EtO/Freon gas
- Water-sealed vacuum pump
- 3 emission points
- Discharge from second floor

APPLICABLE RULES

Rule 201 - Permits
Rule 203 - Information
Rule 702 - VOCs/BACT
Rule 901 - Human Health

ACCEPTABLE CONCENTRATIONS

- Risk of 1 in 1 million
- 1% of TLV

NON-CRITERIA REVIEW

Ethylene Oxide

AAC = 0.03 ug/m3

Freon 12

AAC = 49.5 mg/m3

EMISSIONS

EtO	0.50 pounds per hour
Freon	3.67 pounds per hour

DISPERSION MODELING

- Ground Level Concentration
- Air Intakes

RESULTS

GLC	4.00 ug/m3
Intake	29.71 ug/m3

PERMIT REVISION

- Recirculating vacuum pump
- Acid Scrubber - 99.9+%
- Final EtO Removal System = 99.9+%

COST

Equipment and Piping
$15,500.00

RE-EVALUATION

GLC	0.004 ug/m3
Intake	0.030 ug/m3

APPROVED PERMIT

- 0.26 ppm emission limit
- No visible emissions
- Testing
- Monitoring

TESTING RESULTS

Concentration:

To scrubber - 200,000 ppm
To resin bed - 2 ppm
To atmosphere - Non-detectable

PERMITTING OF ETHYLENE OXIDE STERILIZER AT ST. LUKE'S HOSPITAL

Randal Telesz
Michigan Department of Natural Resources
Air Quality Division

Presented at:

HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP

Hotel Belvedere
Baltimore, MD
May 24-26, 1988

This is how a hospital sterilizer is reviewed in the State of Michigan. St. Luke's is the first hospital sterilizer to be permitted by our Air Quality Division.

In January of 1987, St. Luke's Hospital decided to replace a small ethylene oxide sterilizer with a larger unit and a new aerator. The hospital contacted the Michigan Occupational Safety and Health Agency for information regarding occupational exposure limits from the new sterilizer. It was at this time that the hospital was informed by MIOSHA that the DNR also required a permit prior to installation, so their application was submitted to us on February 2, 1987.

This is the sterilizer on the far right, with the new aerator next to it. The sterilizing chamber is 8.8 cubic feet. The unit that was removed had a 4 cubic foot chamber. The unit is used to sterilize non-wettable surgical instruments and medical equipment.

The sterilizer would use a mixture of ethylene oxide and dichlorodifluoromethane - which is Freon 12. This mixture is 12% ETO, 88% Freon by weight.

- A water sealed vacuum pump would be used to pull a vacuum on the chamber and to exhaust the sterilizing gas at the end of the cycle. The applicant claimed that the ETO would be absorbed by the water in a water separator which would then be discharged to a floor drain. This floor drain had a small vent hood to remove any residual ETO from the drain area at a rate of 100 cfm. The applicant believed that most of the ETO would be absorbed in the water and converted to ethylene glycol. However, the ETO does not hydrolize that fast and is eventually emitted somewhere downstream of the drain.

- In addition to the floor drain exhaust, a hood would be located above the sterilizer door, venting at 200 cfm to remove any residual ETO from the chamber when the door is opened. This exhaust stream would be combined with the floor drain exhaust.

- The third emission point would be from the aerator which had a 100 cfm fan and would exhaust separately from the combined floor drain and door hood.

The two proposed exhaust systems would discharge out the side of the second floor of the hospital.

Upon receipt of the application, I had to determine which rules and regulations applied to the proposed source.

- Rule 201 of the Michigan Air Pollution Control Commission Rules requires a permit prior to installation of any source of an air contaminant.

- Rule 203 requires the applicant to provide all information pertinent to the evaluation of the equipment.

- Rule 702 limits the emissions of volatile organic compounds and requires Best Available Control Technology to be applied to all new VOC sources.

  Rule 901 prohibits the emissions of any air contaminant which may cause injurious effects to human health and unreasonable interference with the enjoyment of life and property.

To protect human health, Michigan has developed acceptable ambient concentrations for non-criteria pollutants, or toxics. For pollutants considered to be carcinogens, the AAC is that annual concentration which would result in an increased cancer risk of one in one million on a lifetime basis. For pollutants which have a Time Weighted Average - Threshold Limit Value, Michigan limits the ambient concentration to 1% of the TLV using an 8 hour averaging time.

Michigan has considered ETO a carcinogen since 1982. The AAC for ethylene oxide is 0.03 ug/m^3 based on Risk Assessment. This is much more limiting than the AAC for Freon 12, which based on 1% of the TLV is 49.5 mg/m^3. These two AAC's must be met by the applicant's source.

For our evaluation of the sterilization process, we made several assumptions with regards to emissions. This was necessary because accurate emission data was not provided by the applicant.

The applicant told us they would be using 0.50 lbs of ETO per cycle and that 90% of the gas would be exhausted during the first evacuation which lasted about 20 minutes. We assumed nothing was absorbed by the materials being sterilized. Three to four additional air washes and purges which last 10 - 15 minutes each, removed 99.98% of the ETO from the chamber. We made the assumption that all of the 0.5 lb of ETO that was put into the chamber was exhausted in one hour at 300 cfm. We calculated the Freon emission rate using the gas weight ratio.

Using the 0.50 lb/hr emission rate for ETO, dispersion modeling was done to determine the maximum ground level concentration on the hospital grounds as well as the concentrations at any air intakes. The source was modeled using an Industrial Source Complex model and was modeled as both a volume and a stack source because the applicant wanted to discharge their exhaust horizontally out the side of the building.

The maximum GLC is determined on the hospital grounds because of public access. The Michigan Air Quality Division has looked at concentrations of air pollutants at hospital air intakes since the early 70's. The ETO is being exhausted to the atmosphere because of the occupational exposure limits so we don't want to see the pollutant being drawn back into the work place as well as the rest of the hospital through the air intakes . . . as is illustrated here with a hospital incinerator.

This is what the dispersion modeling showed. Modeled as a stack source, which was the worst case, the GLC for ETO, located 25 meters from the hospital, was 4.0 ug/m^3. This represents a risk of 1 in 10,000. The maximum intake concentration, 29.71 ug/m^3, occurred 12 meters from the exhaust point on the roof of a 3-story portion of the hospital. This intake concentration represents a risk of 1 in 1,000. These results agree with our experiences in modeling hospital incinerators which show intake concentrations to be about five times the maximum GLC. The maximum GLC for Freon 12 was 0.53 ug/m^3, which was less than the AAC of 49.5 mg/m^3; therefore, the uncontrolled Freon emissions were environmentally acceptable.

The applicant was informed that their ETC emissions and the risk associated with the ambient concentrations were unacceptable, and a permit would not be granted for the equipment as proposed. The applicant was responsible for proving that BACT would be employed to control the emissions and that the resulting emissions would not cause injurious effects to human health or safety.

The applicant proposed the following adendum to their application:

- First, they would replace the once through water-sealed vacuum pump and water separator with a recirculating pump utilizing mechanical seals. This would concentrate the ETO exhaust stream which could then be easily controlled.

- The proposed control equipment consisted of a total recirculating packed column acid scrubber with a 99.9% or greater removal efficiency for the sterilizer exhaust and wash cycles.

- The scrubber discharge would then join the door hood and aerator exhausts, and the combined air flow would pass through the final ETO removal system. This is a proprietary solid reactant bed, where the ETO is absorbed, reacts and remains in the pores of the solid. The removal efficiency for this is also 99.9% or greater.

The control equipment was designed for an air flow of 255 cfm and an exhaust concentration of 260,000 ppm from the sterilizer's first evacuation.

(pic)

This is the rear view of the sterilizer. There are 2 lines exhausting from the sterilizer. The first is a 1¼" line which goes from the sterilizer through the vacuum pump to the scrubber. The second is a copper line which bypasses the vacuum pump and goes directly to the scrubber. This line is used when the positive pressure is being reduced to zero because of problems experienced with water getting into the pump oil.

(pic)

This is the new vacuum pump. The pump runs all the time with an inlet valve that can be closed for the bypass.

(pic)

This is th scrubber. It has 2 packed columns, and a 10 foot^3 recirculating tank which contains a 1N sulfuric acid solution.

(pic)

This is the final ETO removal system. It holds 235 pounds of solid reactant. The inlet from the scrubber is a 1½" line and the inlet from the aerator and door is a 6" duct, both in the top of the picture. The 6" outlet is from the bottom in front.

$15,500 was the cost of the new vacuum pump, the acid column, the recirculation tank, recirculation and return pumps, final ETO removal system, a fan and motor for the exhaust, control panels and all piping.

All of the equipment was installed by hospital personnel, so it was hard to add the installation costs. The supplier also provides annual maintenance services which include changing the acid solution, neutralizing it, and disposing of the weak glycol solution offsite. The scrubber is then recharged with H_2O and acid catalyst, but I don't know what these services cost.

We re-evaluated the emissions from the sterilizer and assumed 99.9% removal efficiency for each piece of control equipment.

Dispersion modeling showed the maximum GLC to be 0.004 ug/m^3 and the air intake concentration to be 0.03 ug/m^3. If you recall, the first modeling showed a GLC of 4.0 ug/m^3 and the intake concentration to be 29.71 ug/m^3. The controlled emissions resulted in ambient concentrations at the ground level and intake that were less than or equal to the AAC of 0.03 ug/m^3.

The final permit was approved in December of 1987 for the sterilizer, aerator and associated control equipment with the following conditions:

1) An emission limit of 0.26 ppm. This is the stack concentration that results in the ambient concentrations we just looked at,

2) No visible emissions are allowed from the sterilizer,

3) Testing may be required for final operating approval,

4) and lastly, the applicant must monitor the ETO concentration prior to and after the solid reactant bed. This must be done at least once a year to determine the breakthrough of the reactant bed for replacement. The supplier has estimated the life of the solid reactant to be 3-10 years.

This shows the final discharge from the side of the second floor. At the time this picture was taken, the stack extension was not complete. However, the final stack is 6" and discharges vertically about 8" below the 45' roof.

Testing of the ETO emission control system at St. Luke's Hospital was done last month.

- During a normal operating cycle, gas samples were taken at the inlet and outlet of both the scrubber and the gas/solid reactor. These samples were analyzed onsite, using a gas chromatograph which was calibrated to .1 ppm.

- The samples were collected when the vacuum pump began to produce a negative pressure in the sterilizer to evacuate the ETO from the chamber.

- The ETO concentration of 200,000 ppm to the scrubber agrees with the typical gases expected which is approximately 20 - 26% ETO by volume in the chamber.

- The 2 ppm ETO concentration to the solid reactor bed did not include the emissions from the door hood and aerator.

- The final concentration to the atmosphere was non-detectable showing the efficiency of the control equipment to be better than originally estimated.

ATMOSPHERIC PERSISTENCE OF EIGHT AIR TOXICS

By Larry T. Cupitt

Presented by:

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Presented at:

HOSPITAL INFECTIOUS WASTE/INCINERATION
AND HOSPITAL STERILIZATION WORKSHOP

Golden Gateway Holiday Inn
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NOTE: EXCERPTS

These Proceedings contain Section 2 only (Conclusions)
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ATMOSPHERIC PERSISTENCE OF EIGHT AIR TOXICS

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SECTION 2

CONCLUSIONS

Relationships have been developed which describe the atmospheric lifetimes of potentially hazardous chemicals in terms of their probable removal mechanisms. These relationships have been applied to eight air toxic chemicals identified by EPA in Intent to List notifications. The eight chemicals and their estimated atmospheric lifetimes are tabulated below.

TABLE 1. ESTIMATED ATMOSPHERIC LIFETIMES OF EIGHT AIR TOXICS

Chemical Name	Atmospheric Lifetime
Methylene chloride	131 days
Chloroform	181 to 378 days
Carbon tetrachloride	50 years
Ethylene dichloride	46 to 184 days
Trichloroethylene	4 days
Perchloroethylene	119 to 251 days
1,3-butadiene	4 hours
Ethylene oxide	217 to 578 days

For all the chemicals except carbon tetrachloride, the dominant removal mechanism was reaction with hydroxyl (OH) radicals. Removal rates for carbon tetrachloride were so slow that the dominant removal mechanism could not be determined, and the lifetime given is one reported elsewhere[1] based upon modeling. Average tropospheric conditions for OH reactions were defined and utilized as the basis of the predicted atmospheric lifetimes for the other chemicals. In the case of ethylene oxide, questions regarding the atmospheric stability of the chemical and the lack of ambient data were addressed and resolved.

The estimated lifetime of butadiene is very short. The tabulated lifetimes were calculated for "average" conditions as were described above. Obviously, the actual lifetime of such a reactive compound will depend upon the specific conditions at the time of release. Because the estimated lifetime is so short, the actual degradation of any real emissions is very dependent upon time of day, sunlight intensity, actual temperature, etc. While the lifetime during the middle of the day in the summer under polluted conditions could be much shorter than the estimated 4 hours, the lifetime of emissions at night could be essentially infinite. After sunset, there will be no hydroxyl radicals generated and the small amounts of residual ozone present in the evening will have little effect on the butadiene concentrations. On average then, 1,3-butadiene has an estimated lifetime of around 4 hours.

ETHYLENE OXIDE

Ethylene oxide (oxirane) is the smallest possible organic epoxide. The nature of the chemical structure induces a high strain energy in the three-membered ring, and this strain energy influences the reaction kinetics and products.[66] Ethylene oxide finds its use as an intermediate in the synthesis of ethylene glycol and as a sterilant or pesticide.[58] The chemical is a mutagen and suspect carcinogen, having been classified as being probably carcinogenic to humans by EPA's Carcinogen Assessment Group.[67]

While ethylene oxide has been monitored in the workplace, data on ambient concentrations of ethylene oxide is very sparse. Brodzinsky and Singh[57] did not report finding any measurements published during the period 1970-80. At this point, no ambient measurements are known.

Two investigators have recently measured the reaction rate constant for ethylene oxide with OH radicals.[13,66] The experimentally determined room temperature rate constants were 5.3 and 8.0 x 10^{-14} cm^3 $molecule^{-1}$ s^{-1}. An activation energy of 2.9 kcal mol^{-1} was measured by one of the investigators across the temperature range 297 K to 435 K. While one should be careful in extrapolating the temperature dependency outside the measured range, it is still reasonable to assume a similar activation energy across the small range to 260 K. Such an assumption does cause greater uncertainty in any lifetime estimates, however. The larger rate constant and the reported activation energy were used to estimate the rate constants shown in Table 13. The choice of the larger rate constant means that the estimated lifetimes are actually on the low side of the possible values.

TABLE 13. ETHYLENE OXIDE REACTION RATE CONSTANTS AND LIFETIMES

Temperature K	OH Reaction Rate Constant 10^{-14} cm^3 molec^{-1} s^{-1}	Assumed [OH] 10^6 molec cm^{-3}	Lifetime days
288	6.9	1.0	167
263	4.3	1.0	217
260	4.0	0.5	578

Of the eight chemicals named in "Intent to List" notifications, ethylene oxide is the most soluble in water. When the concentrations of a chemical in water and air are expressed in the same units (e.g., moles liter^{-1}), the ratio of the aqueous phase concentration to the vapor phase concentration is defined as the dimensionless solubility parameter, α. This value has recently been measured at 288 K and found to be 6.2.[56] This means that ethylene oxide does distribute preferentially into the aqueous phase. Even without considering revolatilization of the chemical, however, rain out will still not be effective in removing the chemical from the environment: the estimated lifetime due to rain out is hundreds of years. Experimental measurements and theoretical modeling of rain out effects have demonstrated little impact from rain out for gases which are even far more soluble than ethylene oxide.[56]

Nor should the chemical distribute into the aqueous phase on ambient aerosols and be removed by deposition of the aerosol. Even a worst case condition of 150 $\mu g\ m^{-3}$ of aerosol, all of it being water, will reduce the gas phase concentration by only one part in one billion. If rapid hydrolysis reactions were to occur to the ethylene oxide dissolved in the aqueous aerosol, that chemical process could increase significantly the loss by this mechanism. Half lives of ethylene oxide in the aqueous phase have been reported[68] to fall between 200 and 400 hours for a wide variety of types of water (e.g., sterile distilled water, sea water, fresh water, sterile and non-sterile river water). Such long lifetimes suggest that hydrolysis reactions in aqueous aerosols are also not likely to be fast.

No other removal process are known which can rapidly deplete the ethylene oxide from the air. Results from smog chamber irradiations[69,70] in both natural sunlight and artificial illumination (private communication, Dr. E. Edney, Northrop Services, Inc., Research Triangle Park, North Carolina) are consistent with a slowly reacting organic chemical: they suggest that there is not some overlooked chemical or photolytic process occurring to remove ethylene oxide. The estimated lifetime, therefore, can be calculated simply from the OH radical removal rate. From Table 13, one estimates the lifetime as 217 to 578 days.

This estimate of lifetime is in disagreement with a previous EPA report by Bogyo et al.[71] and a monograph[72] by SRI International for the National Cancer Institute. Those references conclude that "ethylene oxide is highly reactive and does not persist in the environment" and that epoxides like ethylene oxide are "expected to degrade rapidly" in the environment. The SRI conclusion is based upon an extrapolation of the work by Bogyo et al. Bogyo's conclusions are based upon a few liquid phase experiments which may not be applicable and upon a single 1976 publication by Darnall et al.[73] in which the "reactivity" of various organics was ranked according to their reactivity with OH radicals. Citing the Darnall reference, Bogyo et al. state "ethers as a class (epoxides are a type of ether) have been classified among the most reactive hydrocarbons." That sentence implies that the conclusion of "rapid" removal is based upon a doubtful analogy with unstrained ethers. Darnall et al. do not rank any ethers at all! The only reference to ethers is found in a table copied from an earlier publication[74] which concluded that ethers were capable of producing significant quantities of ozone. It also illustrates a misinterpretation of the literature: the word "reactivity" used in the paper cited by Darnall et al. referred to the ozone forming potential, and not necessarily the rate of removal. The conclusion that ethylene oxide "does not persist" is not warranted, in light of the recent kinetic data.

It is interesting that ethylene oxide, with an estimated lifetime as long as 1.5 years, has not been observed in the ambient atmosphere.[57] A study[75] of breakthrough volumes in Tenax concluded that there was no safe sampling volume for ethylene oxide when using Tenax. It is not surprising, therefore, that previous data from Tenax measurements did not include ethylene oxide. Although Singh et al.[21,22] have carried out a great deal of ambient measurements using a different technique, ethylene oxide was never one of the chemicals which they attempted to measure. In a recent EPA field study using samples collected in polished stainless steel canisters, all attempts to measure ethylene oxide were confounded by an interference from the water peak (private communication, T. A. Hartlage, U.S. EPA, Research Triangle Park, NC). A variety of other methods have been reported in the literature for use in analyzing for ethylene oxide.[67,76-79] These methods all have reported sensitivities from 0.05 parts per million to greater than 3 parts per million. The 1982 estimate[80] for production in the U.S. was 5000 million pounds, or 2270 million kilograms. Assuming that the total Northern Hemispheric production is twice that of the U.S. and that one-fourth of all the material produced is vented to the atmosphere, one calculates an annual input to the Northern Hemisphere of 1.14×10^{12} grams. If the OH radical decay rate is taken as $1/1.5$ year^{-1} and the transfer rate to the Southern Hemisphere is assumed[9] to be $1/1.2$ year^{-1}, one estimates a background concentration in the Northern Hemisphere to be around 240 ppt. This value is a factor of 200 to 12,000 below the quoted analytical detection limits. Even if excursions of factors of 10 to 100 above geochemical background were to occur in urban areas (analogous to some of the observations of Singh et al.[21,22] for other pollutants), the concentrations would still likely be below the detection limit.

It is not surprising then, that no ambient data on ethylene oxide have been reported. Nor does the lack of ambient data argue that there must be some rapid, but unknown, removal mechanism. Until additional data arrive to modify these conclusions, it is appropriate to assign ethylene oxide an atmospheric lifetime of from 0.6 to 1.5 years.

SESSION VIII: HOSPITAL STERILIZERS
NATURE OF THE PROBLEM AND STATE PERMITTING EXPERIENCES

SUMMARY OF DISCUSSION (SAN FRANCISCO)

Q: For which existing EtO sterilizers does the Bay Area AQMD require permits and what special conditions are put on them?

A: (T. Smith, BAAQMD) The Bay Area AQMD just drafted a letter to tell them that they need permits. Part of the initial survey was to get an idea of what the emissions were and from that we decided permitting was necessary. A permit applicability section was added to our regulations; it is a very broad "catch-all" which provides that if a pollution control officer deems that there is an appropriate quantity of toxics present at a given facility, the agency can request a permit application within 90 days.

Q: Is anyone considering the safety issues of the exhaust systems? That is, a fan blowing an explosive mixture near ignition sources?

A: (E. Wade, NY DEC) There is no explosion hazard when using an EtO sterilizer. They are small units and use small concentrations.

(D. Graziani, Hillsborough Co., FL) We know of no explosions in our jurisdiction.

(D. Painter. EPA) EPA is not very worried about having an explosion with the 1288 mixture.

Q: How much does a new sterilizer cost?

A: (Unidentified speaker) The AMASCO unit costs about $30,000.

Q: How are those using risk assessment estimating the concentrations? Is the assumed exposure to a one hour maximum or to an annual average because of the batch process?

A: (D. Graziani, Hillsborough Co., FL) It is a problem because we are using modeling. Since it is a batch process, they claim it is coming out in the first 20 minutes. How can this be modeled? Will we need some site specific monitoring outside the plant? We use the PTPLU model. This gives the worst case impact, and we assume 2 or 3 times the distance of the area of impact as the exposed population. Stack heights are probably 20-25 feet above the building.

(D. Brandt, MI DNR) Michigan takes the one hour worst case emission rate and models as a continuous emission with an annual averaging time. This gives a very high number. Michigan treats all carcinogens the same way and gives no credit to intermittent emissions.

(Eric Wade, NY DEC) New York attempts to estimate realistic exposures likely to occur during the year. For short-term values of EtO, we would use the maximum emissions to occur during the cycle for a one-hour period. For an annual risk assessment model, we would take the maximum emissions to occur during the year given the constraints of the process.

(Tim Smith, BAAQMD) Use of annual average concentrations for a risk assessment is reasonable. In laboratory tests, the animals were probably dosed with a constant concentration throughout their lives. Until someone gives them some intermittent spikes over their lifetime and comes up with a cancer potency, we probably won't know whether our risk assessments are worth anything. In the interim, the best thing is to use the annual average concentration.

Q: Will there be a clearinghouse for this type of information?

A: (D. Painter, EPA) Contact the EPA Control Technology Center in Research Triangle Park, NC.

SESSION VIII: HOSPITAL STERILIZERS
NATURE OF THE PROBLEM AND STATE PERMITTING EXPERIENCES

SUMMARY OF DISCUSSION (BALTIMORE)

Q: What is the status of the new H_2O_2 process?

A: (D. Graziani, Hillsborough Co., FL) Its effectiveness is limited and it has only been demonstrated on a small scale. It will not replace the EtO process.

Q: Because sterilization is a batch process the discharge to the atmosphere is intermittent. How persistent in the environment is EtO?

A: (D. Graziani, Hillsborough Co., FL) Cupitt 1987 [excerpts reprinted in these Proceedings; see presentation by Darrell Graziani] estimated that EtO lasts for 217 to 578 days.

(D. Painter, EPA) Ultraviolet photolysis can affect the persistence of EtO in the atmosphere. Its life in wastewater may be longer.

Q: EtO hydrolyzes in the presence of water to ethylene glycol. Could this reaction be employed in an air pollution control, e.g. for fugitives?

A: (D. Painter, EPA) EtO is soluble in water but it may reach equilibrium rapidly, so pH may have to be altered in order to drive the reaction to produce ethylene glycol. Applicability as a control technique is uncertain.

(R. Waterfall, NY DEC) A very large catheter manufacturing plant in Glens Falls, New York, installed an acid hydrolysis scrubber for EtO.

Q: What are the water pollution impacts of EtO?

A: (R. Telesz, MI DNR) When the water goes into the sewer, the EtO aerates out into the headspace and vents. It is probably gone by the time the water reaches the treatment plant.

Q: A study by Hillsborough County (Florida) of 17 hospital facilities indicates a need for EPA to promulgate a NSPS for sterilizers, analogous to the NSPS for wood stoves.

Q: Regarding Freon emissions: substitution of CO_2 or N_2 for Freon could be a significant issue.

A: (J. Gray, Consumat Systems, Inc.) A switch to N_2 is feasible. The gas mixture is well below the explosive range when using N_2. Problems have arisen with the use of CO_2, so CO_2 is not being used.

A possible approach is to require Freon controls on large facilities, and follow the NSPS specifying N_2 and a scrubber on small units.

Q: Could sterilizers be vented to existing hospital incinerators?

A: (J. Gray, Consumat Systems, Inc.) Sterilization is a batch process with 2-20 cycles per day. Hospital staff would not be able to coordinate incineration and sterilization.

Q: Could sterilizer emissions be controlled with a small afterburner to flare off the EtO/N_2 mixture?

A: (D. Graziani, Hillsborough Co., FL) This apparently has not been tried, but it seems feasible.

SESSION IX

WRAP-UP

SESSION IX: WRAP-UP DISCUSSION

SUMMARY OF DISCUSSION (SAN FRANCISCO)

Q: Except in a non-attainment area, it is usually not necessary to look at particulates. Are the particulates being used as a "back door" means of estimating how well the organics are controlled?

A: (D. Painter, EPA) The 0.015 gr/dscf is based on actual test data. If you are doing a BACT determination, you must consider that.

Dry scrubbers, ESPs, and bag houses have also demonstrated control levels down to that area. Particulate collection at that efficiency will also filter dioxins. This high degree of control is generally desirable.

Q: There are policy questions on how to control the smaller units and whether there should be a size threshold for exemptions. Small units may expose a local population to high risks. Large regional facilities may expose a larger population to lower risks, and they raise transportation issues.

Q: What is the status of federal regulations?

A: (D. Painter, EPA) EPA is in the beginning stages of writing regulations. The Source Category Survey leads into Phase I which is a much more detailed look at the industry. For the next step under the Clean Air Act there are two sections that apply: sections 111(b) (NSPS) and 111(d). The NESHAP process (section 112) is also a possibility. However, under NESHAP, it is very hard to promulgate regulations, so the alternative is section 111.

A model to follow may be municipal waste combustion, which can be regulated as coke ovens are: call it municipal waste emissions and monitor parameters such as particulates and CO. Particulates are an indicator of the performance of "tail end" controls. CO indicates combustion control, and good combustion is the strategy needed to control dioxins.

Congress has not taken action. Clean Air Act amendments will probably take another year to a year and a half. RCRA may be applied to hospitals and hospital waste incineration.

SESSION IX: WRAP-UP DISCUSSION

SUMMARY OF DISCUSSION (BALTIMORE)

Q: The final disposal of ash receives inadequate attention.

A: (D. Painter, EPA) EPA is doing research on ash toxicity. A study expected to show that ash toxicity was no problem concluded the opposite, so efforts have been increased. EPA favors incineration to reduce the volume to be landfilled. For information call the Air Research Laboratory at EPA Control Technology Center, Research Triangle Park, North Carolina (919) 541-0800.

(V. Ozvacic, ON Min. of Env.) Canadian agencies are studying the leaching of metals from ash. The Ontario Ministry of the Environment has guidelines on trace metals and organics, so they are studying the question of ash toxicity. Environment Canada has also done research in this area.

(T. Dydek, TX ACB) A paper on leaching of metals from municipal waste ash appeared in the Journal of the Water Pollution Control Federation for November, 1987 (Volume 59, page 979).

Q: Anecdotal evidence suggests that ash may contain identifiable objects even if it meets a 5% fixed carbon criterion.

Q: Florida has permitted several municipal waste incinerators with dry scrubbers and baghouses, that can meet a specification of 1800° for 2 seconds. What problems should be expected in burning hospital waste in these facilities?

A: (D. Painter, EPA) Workers do not want to handle waste when they see red bags.

Waste must be charged carefully since a sudden, excessive load of medical waste could cause upset, slagging, or unburned objects in the ash. Also, the plastic red bags can ignite prematurely in the charging area.

Regional facilities must deal with potential waste transportation problems.

Wisconsin favors a dedicated facility for hospital waste, so that the staff is familiar with and trained specifically for hospital waste.

The use of buckets in Wisconsin to collect sharps seems to be a good idea.

In Washington (state), a municipal facility is burning large amounts of hospital waste, resulting in community concern. The state agency is addressing the questions raised.

Q: (Unidentified speaker) Prince George's County, Maryland, requires that waste be boxed after it is bagged, and then be delivered to a specialized commercial incinerator. Worker concerns (leakage, breakage, injury from sharps) are resolved if the waste is boxed. This technique minimizes public concern and worker exposure, and could be included in a Federal rule or state regulations.

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Hospital Infectious Waste Incineration/
Hospital Sterilization Workshop
May 10-12, 1988
San Francisco, CA

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May 24-26, 1988
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